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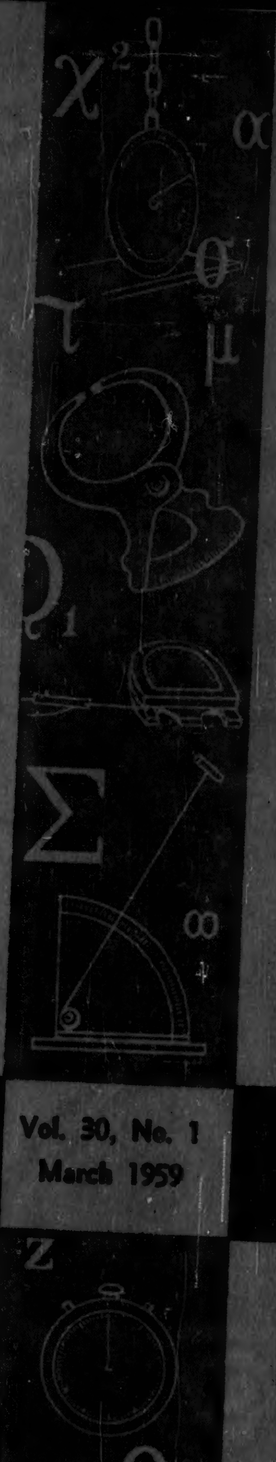

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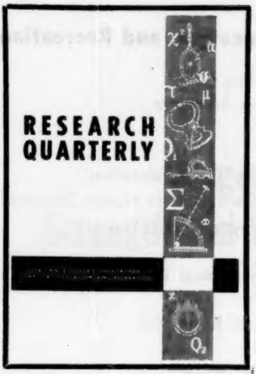

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CONTENTS

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Oregon Simplifications of the Strength and Physical Fitness Indices[1]

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Abstract

After experimentation with chronological age and eight anthropometric tests, weight and age were found to have the highest multiple correlation with the Strength Index and were chosen as the basis for norms. The following multiple correlations were obtained between the Strength Index and the various test items composing the SI battery: for upper elementary school boys, .977 for leg lift, back lift, and push-ups; for junior high boys, .987 for leg lift and Rogers' arm strength score, .998 when right grip was added; for senior high school boys, .985 for leg lift and Rogers' arm strength score, .996, when back lift was added. Regression equations were computed for each of these multiple correlations.

Statement of Problem

THE STRENGTH INDEX (SI) battery consists of four strength tests (right and left grip, back and leg lifts), two muscular endurance tests (pull-ups, push-ups), and lung capacity. The SI is derived as the gross score obtained from these seven tests. The Physical Fitness Index (PFI) is obtained by dividing the achieved SI by a norm for the individual's sex, age, and weight and multiplying this quotient by 100. The median PFI score for a random population is 100; the first and third quartiles are 85 and 115 respectively. The Strength Index is intended as a test of general motor ability; the Physical Fitness Index is proposed as a test of basic fitness elements.

While the SI and PFI have been effectively used in school and college physical education programs, many users readily acknowledge that the following factors prevent more general use: (1) cost of testing equipment, (2) time required for giving the test to many students, and (3) necessity for well-

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[1]This study was conducted with data obtained from the Medford, Oregon, Growth Study. Subsidization of the Growth Study was provided by Medford Public Schools, Southern Oregon College, Athletic Institute (Chicago, Ill), and University of Oregon. Acknowledgments for testing assistance are made to the following University of Oregon and Southern Oregon College students: Dale Bates, David H. Clarke, James C. E. Harrison, Noel R. Hayman, Robert Irving, Boyd O. Jarman, Ronald Mauer, Kay H. Petersen, and J. Stuart Wickens. The Superintendent of the Medford schools, Dr. Leonard A. Mayfield, and the Director of Physical Education, Lee Ragsdale, as well as Theodore Schopf, Southern Oregon College, are also recognized for their assistance.

trained testers. As a consequence, this research was undertaken to seek a simplification of this battery for boys at each of the following three school levels: upper elementary school, junior high school, and senior high school. Two problems were undertaken: a re-study of the measures upon which to base Strength Index norms and an investigation of whether approximately similar results could be obtained if test items were eliminated.

The subjects were 356 boys in the Medford, Oregon, public schools. The upper elementary school ages were restricted to 9, 10, and 11 years; the junior high school ages, to 12, 13, and 14 years; the senior high school ages, to 15, 16, and 17 years. Forty boys served as subjects at each age except 17 years, where the number was 36. Subsequently, these boys were found to by physically superior to normal populations, inasmuch as their mean PFI's were 111 for upper elementary school, 120 for junior high school, and 108 for senior high school; the mean PFI for all subjects was 113.

The PFI testing techniques utilized in this study were in accordance with those described by Clarke (1). The tests were administered during the 1956-57 school year by undergraduate and graduate students from the University of Oregon and Southern Oregon College.

Bases for Strength Index Norms

The first phase of this research was devoted to a re-study of the measures upon which norms for the Strength Index should be based. In the original research by Rogers (4), only age, height, and weight were considered. In addition to these three measures, the following six anthropometric tests were included in this study: sitting height, leg length, flexed-tensed upper arm girth, chest girth, calf girth, and hip width.

The multiple correlations obtained between the Strength Index and the two variables producing the highest coefficients at each school level were as follows:

Upper elementary school: .59 with standing height and flexed-tensed upper arm girth.

Junior high school: .79 with sitting height and flexed-tensed upper arm girth.

Senior high school: .68 with tensed-flexed upper arm girth and sitting height.

These correlations were quite low for predictive purposes, so the selected test items at each school level were considered of questionable value as a basis for SI norms. In determining the above relationships, also, age in each instance was limited to three years, which had a partialling effect on the correlations; in the original research on the norms, age ranged over many years. As a consequence, the relationship of age, height, and weight to the Strength Index was studied for the combined ages, 9 to 17 years inclusive, utilizing the scores of all 356 Medford boys. The resulting multiple correlation was .901 between the SI and weight and age; the addition of height

to the computation did not increase this amount. This correlation was .043 correlational points higher than the .858 obtained originally by Robers (4). As a consequence of this evidence, the decision was made to continue the use of weight and age as the basis for Strength Index norms.

It was further decided that the Rogers norms, which were last constructed in 1938, would be utilized to determine Physical Fitness Indices in this study. This action was justified on the assumption that these norms are still fairly representative of the strength status of schoolboy populations at the ages included in this study. This assumption is supported by the results of PFI testing done in 11 widely dispersed high schools in Oregon during 1955-56, in which approximately 1500 boys were tested (2). The scores from the initial testing in these schools compared reasonably well with expectations reflected by the 1938 norms: for all boys, the median PFI was 98, as contrasted with 100; the Q-1 was 84, as compared with 85; the Q-3 was 109, which was definitely below the 115 expected. The findings from PFI testing elsewhere, in general, show similar patterns, although the Q-3 is not usually as low (3).

The question of "normal" physical populations is complicated by the nature of physical education in the schools from which the population is drawn. An example is the Medford sample used in this study, in which the mean PFI's are especially high. It is judged that strong, well-balanced physical education and athletic programs have been in operation for several years. In a study by Whittle (5), 12-year-old boys from good elementary school physical education programs had much higher mean PFI's than did those from poor programs; they were also superior in a number of other physical measures applied in his study. ("Good" and "poor" physical education programs were judged by use of a modified form of the LaPorte score card.) At any rate, generally speaking, the PFI norms do not appear too high for current use.

Simplification of Indices

This phase of the study involved the selection of those test items for boys in each age group which had high correlations with either the Strength Index or the Physical Fitness Index. This process included the computation of multiple regression equations for use in predicting the appropriate total battery scores. Regression equations were computed only when the multiple correlations reached the high .90's. In addition to the SI test items, two arm strength scores derived from the Rogers and McCloy formulae were included. Both of these formulae are based upon the number of pull-ups and push-ups.

Product-Moment Correlations

The product-moment intercorrelations among the various test items and the correlations of these items with the Strength Index and the Physical Fitness Index for boys at the three school levels are presented in Table 1. Both the Rogers and McCloy arm strength scores are included, as they are based on

pull-ups and push-ups. Observations concerning these relationships are as follows:

1. The highest intercorrelations among the test scores at each of the school levels were with Rogers arm strength and push-ups; these were .94, .80, and .86 at the upper elementary, junior high, and senior high school levels respectively. Pull-ups correlated slightly lower with this arm strength score at the three levels. The correlations of Rogers arm strength score with the other test items were insignificant (.01 to .21) for the elementary school boys but were significant and relatively high for the junior and senior high school boys.

2. The McCloy arm strength score generally had high correlations with the gross strength tests, such as the grip tests and the back and leg lifts, but had low correlations with the number of pull-ups and push-ups, as contrasted with the Rogers arm strength score. Furthermore, the McCloy score correlated about as well for the elementary school boys as it did for those of junior and senior high school ages.

3. The correlations between right and left grip strengths at the three school levels were .77, .87, and .72. Right grip correlated fairly well with back lift and leg lifts and lung capacity. Although the correlations were generally lower, the same was true for left grip strength. For each test, the correlations with right and left grip strengths were higher for the junior high school boys than for the boys at the other school levels; the highest such correlation was .84 between grip and back lift.

4. The correlations between pull-ups and push-ups for the three school levels were .78, .74, and .63. The correlations of these two tests with the other test items were low; most of these were not statistically significant.

5. Back lift, leg lift, and lung capacity correlated much higher with the other test items for the junior high school boys than at either the upper elementary or senior high school levels.

6. The highest correlations between a single test item and the Strength Index at the three school levels were .92, .96, and .90, with leg lift as the test. Other relatively high correlations with this criterion were as follows: .65, .89, and .86 with McCloy's arm strength score; .64, .83, and .73 and .59, .84, and .68 for left and right grips respectively; .67, .81, and .74 for back lift; .56, .80, and .64 for lung capacity; .35, .82, and .77 for Rogers' arm strength score. Much lower correlations were obtained between the Strength Index and pull-ups and push-ups. The correlations for the junior high school boys were consistently higher than for the other two school levels.

7. With the Physical Fitness Index as criterion, the highest correlations obtained at the three school levels were as follows: .69, .56, and .41 with leg lift; .60, .69, and .65 with Rogers' arm strength score; .57, .73, and .66 with pull-ups; and .58, .72, and .70 with push-ups.

TABLE 1.—INTERCORRELATIONS OF TEST ITEMS AND THEIR CORRELATIONS WITH THE STRENGTH INDEX AND THE PHYSICAL FITNESS INDEX FOR UPPER ELEMENTARY, JUNIOR HIGH, AND SENIOR HIGH SCHOOL BOYS

	Left Grip			Back Lift			Leg Lift			Lung Capacity			Pull-Ups			Push-Ups			Rogers' Arm Str.			McCloy's Arm Str.			Strength Index			Phys. Fitness Index		
Test Items	El[a]	Jr	Sr	El	Jr	Sr	El	Jr	Sr	El	Jr	Sr	El	Jr	Sr	El	Jr	Sr	El	Jr	Sr	El	Jr	Sr	El	Jr	Sr	El	Jr	Sr
Right Grip	.77	.87	.72	.56	.84	.60	.46	.72	.61	.61	.76.	.64	.00	.29	.11	.09	.27	.27	.18	.62	.51	.64	.81	.76	.64	.83	.73	.20	.31.	13
Left Grip				.43	.77	.53	.43.	77	.55	.55	.74.	57	.00	.28	.13	.12	.31	.30	.20	.61	.51	.60	.75	.67	.59	.84	.68	.19	.40	.14
Back Lift							.44	.71	.51	.43	.65	.53	.04	.27	.19	.03	.22	.33	.12	.58	.51	.48	.67	.68	.67	.81	.74	.41	.35	.20
Leg Lift										.49	.72	.54	.06	.32	.10	.15	.36	.25	.21	.68	.46	.48	.82	.71	.92	.96.	90	.69	.56	.41
Lung Capacity													-.18	.14	-.01	-.06	.23	.11	.01	.56	.36	.55	.80	.66	.56	.80	.64	.12	.23	.01
Pull-Ups																.78	.74.	63	.89	.74	.69	.19	.37	.22	.17	.44	.34	.56	.73	.66
Push-Ups																			.94	.80	.86	.39	.39	.45	.27	.49	.53	.58	.72	.70
Rogers' Arm Strength																						.49	.72	.69	.35	.82	.77	.60	.69	.65
McCloy's Arm Strength																									.65	.89	.86	.23	.28	.15

[a]El: Upper elementary school; Jr: Junior High School; Sr: Senior High School.

Multiple Correlations

The multiple correlations obtained with the Strength Index and the Physical Fitness Index as the criterion measures were as follows:

School Levels	*Criteria*	*R*	*Independent Variables*
Upper Elementary	PFI	.871	Leg lift, pull-ups, lung capacity
	SI	.977	Leg lift, back lift, push-ups
Junior High School	PFI	.849	Pull-ups, leg lift, push-ups, lung capacity
	SI	.987	Leg lift, Rogers' arm strength score
		.998	Leg lift, Rogers' arm strength score, right grip
Senior High Scool	PFI	.796	Push-ups, pull-ups, leg lift
	SI	.985	Leg lift, Rogers' arm strength score
		.996	Leg lift, Rogers' arm strength score, back lift

The multiple correlations with the SI as the criterion were found to be higher at all school levels than when the PFI was the dependent variable: .977 to .998 for the SI and .796 to .871 for the PFI. Leg lift appeared in all eight multiple correlations; it was the first variable in the five SI and one of the PFI multiple batteries. In general, pull-ups and push-ups correlated better with the PFI than did the other tests; the Rogers arm strength score was an important variable in the SI multiple correlations.

Multiple Regression Equations

Inasmuch as the multiple correlations with the Strength Index as criterion were all high, .977 and above, multiple regression equations were computed for them. Two equations are presented at both the junior and senior high school levels, so that the physical educator may choose whether he wishes to utilize only the leg lift and arm strength, thus limiting his testing to a minimum, or to add another test item at each school level, thus obtaining a closer approximation of each boy's actual SI. The multiple regression equations thus computed are as follows (the arm strength scores are by Rogers' formula):

Upper Elementary School Boys

$$R = .977$$

$$SI = 1.05 \text{ (leg lift)} + 1.35 \text{ (back lift)} + 10.92 \text{ (push-ups)} + 133$$

σ est. = 43

Junior High School Boys

$$A{:}\ R = .987$$

$$SI = 1.33 \text{ (leg lift)} + 1.20 \text{ (arm strength)} + 286$$

σ est. = 76

$$B{:}\ R = .998$$

$$SI = 1.12 \text{ (leg lift)} + .99 \text{ (arm strength)} + 5.19 \text{ (right grip)} + 129$$

σ est. = 30

Senior High School Boys

$$A: R = .985$$

$$SI = 1.22 \text{ (leg lift)} + 1.23 \text{ (arm strength)} + 499$$

$$\sigma \text{ est.} = 86$$

$$B: R = .996$$

$$SI = 1.07 \text{ (leg lift)} + 1.06 \text{ (arm strength)} + 1.42 \text{ (back lift)} + 194$$

$$\sigma \text{ est.} = 44$$

The second, or B, regression equations for the junior and senior high school boys, of course, approximate each boy's actual SI with a greater degree of accuracy than do the first, or A, equations. The degrees of accuracy are reflected in the standard errors of estimate: for the junior high school boys, this error is approximately 2.5 times greater for the A equation; for the senior high school boys, this error is about twice as large.[2]

These regression equations were tested by comparing the actual PFI's with the PFI's predicted by the application of each of the regression equations. This tabulation is shown in Table 2.

TABLE 2.—COMPARISON OF ACTUAL AND PREDICTED PHYSICAL FITNESS INDICES FOR ELEMENTARY, JUNIOR HIGH, AND SENIOR HIGH SCHOOL BOYS

School Level	Equation	Means		Mean Diff.	Standard Deviation of Differences
		Actual	Predicted		
Elementary School		110.8	111.8	+1.0	4.3
Junior High School	A	120.4	120.7	+ .3	6.3
	B	120.4	121.1	+ .7	4.0
Senior High School	A	108.2	109.9	+ .7	4.6
	B	108.2	109.2	+1.0	3.1

Thus, the differences between the actual and predicted PFI means at the three levels and for all equations ranged from .3 to 1.0 PFI points. In all instances the predicted PFI means were higher. The standard deviations of the differences between actual and predicted PFI's ranged from 3.1 to 6.3. As would be expected from the higher multiple correlations, the B equations resulted in smaller standard deviations for both the junior and senior high school boys.

Conclusion

The Oregon simplifications of the Strength and Physical Fitness Indices are presented in an effort to secure more strength testing of this sort in the public schools. Obviously, the simplified versions do not require as many pieces of testing apparatus as does the full test, although a back and leg dynamometer is still necessary. Also, the simplifications can be given more

[2]Mimeographed tables for ready computation of all regression equations may be obtained upon request to the senior author.

rapidly and with fewer testers than the complete test. Testing skill is still a requisite, especially for the dynamometer tests. For those who are disatisfied with approximations, however, the full test should be given.

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(Submitted 5/9/58)

Effects of Various Warm-Up Procedures on 100-Yard Times of Competitive Swimmers

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Abstract

The purpose of this study was to determine the values that can be ascribed to the warm-up procedures customarily employed by competitive swimmers (hot showers, calisthenics, massage, and swimming). Thirteen subjects swam a total of 195 time trials. Each swimmer swam three 100-yard time trials with no warm-up and three time trials after each of the four warm-up procedures.

The group as a whole showed significant improvement only following the swimming warm-up, whereas the breast-strokers and dolphin swimmers as a group had their best and significant improvement following calisthenics. The free stylers as a group showed a significant decrease in speed in their trials after calisthenics warm-up.

THE PRACTICE of warming up before engaging in any competitive athletic activity has been a widely accepted procedure. The experimental evidence concerned with this practice is not conclusive either as to the value of the warming up process or the best means of warming up for specific sports. It was the purpose of this study to investigate the merits of some of the more commonly used methods of warm-up for competitive swimmers.

Review of Literature

With the exception of Karpovich (10), textbooks of exercise physiology (8, 14, 16, 17) ascribe some advantages to the procedure of warming up. Some of these advantages are (1) the benefit of the treppe effect, (2) increase in body and/or muscle temperature, (3) elimination of the possibility of a contracture, (4) shortening of the length of the muscle relaxation period, (5) improvement of the muscle tone, and (6) improvement of the general circulation.

Experimental evidence available at the present time is not in agreement regarding the values to be derived from warming up. The studies of Asmussen and Boje (1), Barch (2), Burke (4), Blank (5), Carlile (6), and Thompson (21) seem to substantiate the theory of warming up athletes, while the studies of Hipple (9), Karpovich and Hale (11), Sills and O'Riley (19), and Skubic and Hodgins (20) do not demonstrate statistically significant differences in performance after warming up as compared with controls.

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[1]This study was conducted under the direction of Dr. Aileene Lockhart at the University of Southern California, Los Angeles, 1957.

Carlile (6) found approximately a 1 percent improvement in 40-yard swimming time trials following eight-minute hot showers. Thompson (21) also found significant improvement in swimmers' times after a formal swimming warm-up.

Methods and Procedure

It was the purpose of this study to investigate the values of four commonly used methods of warm-up for highly skilled competitive swimmers. These four warm-up methods were: (1) swimming, (2) hot shower, (3) calisthenics, and (4) massage. Time trials after each of these warm-up methods were compared with each other and with time trials done after controlled conditions of no warm-up.

There were several important limitations to this study which should be mentioned. First, the only aspect of the problem considered in this study was improvement of performance. Other possible advantages of warming up such as prevention of injuries were considered beyond the scope of this experiment. Also there were variables which were impossible to control, such as diet and sleep habits of the subjects. The short time that it was possible to allot to warming up by massage must be considered a serious limitation to any conclusions that might be drawn regarding the value of massage as a warm-up procedure. It might also be considered a limitation of the study that the subjects, in taking hot showers as a warm-up procedure, were instructed to adjust the mixing valve for the hot shower temperature as hot as they could stand it, instead of holding a definite temperature for all subjects. However, it was felt that this procedure might better take into account the the individual differences in reaction to hot water that were reported by Carlile (6). This also provided a practical method which could be used by the swimming coach, whereas a definite assigned temperature possibly could not.

SUBJECTS

The subjects were the combined memberships of the freshman and varsity swimming teams of the University of Southern California, making a total of 13 highly skilled competitive male swimmers. These 13 subjects were divided into five groups on the basis of their events. Thus the five groups consisted of (1) four free-style sprinters, (2) three free-style distance men, (3) one backstroker, (4) two breaststrokers, and (5) three dolphin men.

WARM-UP METHODS

The warm-up methods selected for this experiment were chosen for their relatively wide use and their practicability under meet conditions for competitive swimmers.

Swimming Warm-Up. Since the swimmers had by this point in their careers already well-formulated ideas regarding swimming warm-up, they were al-

lowed to swim as they saw fit with the stipulation that they swim 500 yards slowly and continuously.

Shower Warm-Up. For this warm-up the swimmers were instructed to shower for six minutes under a shower with an automatic mixing valve keeping the temperature of the shower as hot as they could stand it. This time was selected because Carlile (6) found eight minutes to be too long for at least one of his subjects. The subjects were supervised during this showering period.

Calisthenics Warm-Up. The exercises selected were taken from Kiphuth (12). His exercises were used as follows: exercise number one for spreading the ribs, flexing the hips, and stretching the long back muscles for 25 repetitions; exercise number four for stretching the chest muscles, abdominals, and hip joint flexors, and strengthening lower back muscles for 15 repetitions; exercise number seven for strengthening abdominals and hip joint flexors for 100 repetitions; exercise number eight for strengthening extensor muscles of lower back and hip for 20 repetitions; exercise number 14 for strengthening all the back muscles for 100 repetitions; and exercise number 15 for strengthening the abdominals and hip joint flexors for 40 repetitions. The above exercise numbers refer to the exercises as numbered in the reference. These exercises were chosen because the coach and swimmers were familiar with them and because Kiphuth is widely recognized as an authority on swimming.

Massage Warm-Up. It was felt that if the massage warm-up was to be of any practical value, it would have to be administered by the swimmers upon one another. This was considered necessary because very few swimming coaches have the services of a trainer or masseur.

The pressure of time precluded the use of a complete massage which, according to Baumgartner (3), should take from 45 minutes to one hour. Under the limitations of this experiment, it was possible to allow only 10 minutes of massage per swimmer. This lack of time and skilled masseurs posed serious limitations upon the conclusions that can be drawn regarding the warm-up value of massage.

The swimmers were instructed in the use of massage and were supervised at all times. The massage started with the back, then the legs, then the arms and shoulders, after which the subject was asked to assume the supine position and the massage was continued with the chest, the legs, and the arms in that order. The massage movements used on all areas were friction, pettrissage, and effleurage, in that order.

Criterion of Swimming Speed

The criterion of swimming speed was arbitrarily selected as a 100-yard swim timed by two experienced swimming timers using the same two watches throughout the entire experiment. The watches were checked one against the other each day and were never found to vary as much as 0.1 second. The

swimmers were started by gun start with the standard NCAA start. Each swimmer took his time trials in his own specialty stroke, swimming alone in an all out effort which in every case approached his competitive times.

General Procedure

Each swimmer swam a total of 15 time trials, making a total of 195 time trials. Each swimmer swam three of these trials after acting as a control, in which case he had had no warm-up activity or physical activity of any kind other than walking to and from classes for a period of at least one hour preceding the time trial. The remaining 12 time trials were taken, three following each of the four warm-up procedures. The swimmers took only one time trial per day three days per week for a period of five weeks.

TABLE 1.—METHOD OF ROTATION OF WARM-UP PROCEDURE BY DAY

Day	Sprinters	Distance	Backstrokers	Breaststrokers	Dolphin
1	Control	Swim	Shower	Calisthenics	Massage
2	Swim	Shower	Calisthenics	Massage	Control
3	Shower	Calisthenics	Massage	Control	Swim
4	Calisthenics	Massage	Control	Swim	Shower
5	Massage	Control	Swim	Shower	Calisthenics
6	Control	Swim	Shower	Calisthenics	Massage
7	Swim	Shower	Calisthenics	Massage	Control
8	Shower	Calisthenics	Massage	Control	Swim
9	Calisthenics	Massage	Control	Swim	Shower
10	Massage	Control	Swim	Shower	Calisthenics
11	Control	Swim	Shower	Calisthenics	Massage
12	Swim	Shower	Calisthenics	Massage	Control
13	Shower	Calisthenics	Massage	Control	Swim
14	Calisthenics	Massage	Control	Swim	Shower
15	Massage	Control	Swim	Shower	Calisthenics

A schedule of rotation of warm-up and control (Table 1) was set up to minimize the effects of day to day variation and the improvement expected due to training over the five-week period.

All warming up and all time trials were done prior to the team's regular workout, and all time trials were taken as nearly as possible immediately following the warm-up procedure. The duration of the experiment was five weeks and encompassed the periods of time usually referred to as late preseason and early season in respect to the team's progress.

Treatment of the Data

The first problem under consideration was the question of how much improvement had occurred in the swimmer's time trials due to the effects of training during the five-weeks duration of this experiment. Thus the mean of each swimmer's first five time trials was compared with the mean of his last five time trials. The M of these differences was –0.15 seconds. Applying small sample statistics for the significance of the difference of

correlated M's, a t value of 1.01 was found. With 12 degrees of freedom a t of 2.179 is needed for the 5 percent level of confidence. It may therefore be concluded that this difference can be attributed to sampling error in a population whose mean differences would be zero, so that this training factor probably did not affect the experiment.

The second problem considered was the question of how much effect the various warm-up procedures had upon the swimmers' time trials when comparing all the swimmers regardless of stroke used. In order to determine whether any of the observed mean differences (Table 3) differed significantly from the differences which might be expected to arise by chance through sampling errors, an analysis of variance was done. Since there were two possible sources of experimental variance in the study, namely variance due to warm-up procedure and variance due to the stroke swum, it was decided to use the "type I design" of Lindquist (13). The F ratio due to warm-up effect was 6.1418, which is significant at better than the 1 percent level of confidence. The F ratio for the interaction between the warm-up effect and the stroke swum was 7.1280, which is also significant at better than the 1 percent level of confidence. The analysis of variance is presented in Table 2.

To determine where these differences might lie, the data were subjected to the Fisher t test for the significance of differences between means in small correlated samples. It was found that where all swimmers' times were compared regardless of stroke, the only mean difference which was significant at the 5 percent level of confidence was the improvement in time of .44 seconds after swimming warm-up compared with control times.

TABLE 2.—VARIANCE ANALYSIS OF DIFFERENCES IN SWIMMING TIMES FOR WARM-UP (A) AND STROKE (B)

Source of Variance	d.f.	Sums of Squares	Mean Square	F	Signif.
Between Subjects	11	5524			
Between Strokes (B)	3	4682			
Within Subjects	48	16.4			
for warm-up (A)	4	2.84	.71	6.14	.01
for interaction (AB)	12	9.9	.824	7.13	.01
Error	32	3.7	.1156		
Total	59	5541.4			

It was felt, after examining the times the swimmers had done, that for purposes of comparison the free style sprinters and distance men made up a homogeneous group and the breaststroke and dolphin men also made up a

TABLE 3.—MEAN TIME[a] FOR EACH SWIMMER FOLLOWING VARIOUS WARM-UPS AND COMPARISON WITH MEAN TIME FOLLOWING CONTROL

Subject		M. for 3 Control Swims	M. for 3 Swim Warm-ups	Diff. from Control	M. for 3 Shower Warm-ups	Diff. from Control	M. for 3 Cal. Warm-ups	Diff. from Control	M. for 3 Massage Warm-ups	Diff. from Control
Sprint	1	58.0	57.3	− .7	57.7	− .3	58.0	0	58.3	+ .3
	2	55.0	54.9	− .1	54.6	− .4	55.7	+ .7	54.6	− .4
	3	53.8	53.6	− .2	53.6	− .2	54.0	+ .2	54.1	+ .3
	4	56.0	56.2	+ .2	56.9	+ .9	56.7	+ .7	57.1	+1.1
Distance	5	56.0	55.3	− .7	57.7	+1.7	55.9	− .1	55.9	− .1
	6	59.4	59.1	− .3	59.5	+ .1	59.7	+ .3	59.2	− .2
	7	55.2	55.4	+ .2	55.6	+ .4	56.0	+ .8	57.0	+1.8
Back	8	70.2	69.6	− .6	69.9	− .3	69.7	− .5	70.6	+ .4
Breast	9	73.3	72.6	− .7	74.6	+1.3	71.5	−1.8	72.0	−1.3
	10	87.7	87.2	− .5	87.1	− .6	86.7	−1.0	86.1	−1.6
Dolphin	11	66.8	65.1	−1.7	65.8	−1.0	64.5	−2.3	65.0	−1.8
	12	64.6	63.3	−1.3	63.5	−1.1	62.4	−2.2	63.6	−1.0
	13	72.6	73.3	+ .7	73.2	+ .6	72.3	− .3	73.8	1.2

[a]All times are in seconds, and differences are expressed as plus or minus as the time after warm-up was greater or less than the control time respectively.

TABLE 4.—COMPARISON OF THE MEAN SWIMMING TIMES[a] FOLLOWING VARIOUS WARM-UPS WITH THEIR MEAN CONTROL TIMES

Group	No. of S's	M. diff. for Swim Warm-up	S.E. of M. diff.	t ratio	M. diff. for Hot Shower	S.E. of M. diff.	t ratio	M. diff. for Calisthenics	S.E. of M. diff.	t ratio	M. diff. for Massage	S.E. of M. diff.	t ratio
Whole	13	−.44	.176	2.50[b]	+.08	.237	.36	− .42	.300	1.40	−.10	.308	.32
Free Style	7	−.23	.440	.53	+.33	.284	1.16	+ .37	.139	2.66[b]	+.40	.298	1.35
Breast and Dolphin	5	−.70	.410	1.71	−.16	.480	.33	−1.52	.38	4.00[b]	−.90	.540	1.67

[a]All times are in seconds or decimal fractions thereof and plus and minus are used to indicate a mean difference which was the result of warm-up times greater or less than the control time respectively.
[b]Significant at the 5% level of confidence.

homogeneous group. This was felt to be so for two reasons: (1) the times within these two groups would now be comparable as to magnitude, and (2) the free stylers, regardless of whether sprinters or distance men, swim with a far more continuous motion, due to the alternating arm action, than do the breaststrokers and dolphin men, who have a phase in their strokes when neither arm is propulsive and consequently must exert a greater force during the propulsive phase.

The free stylers (both sprinters and distance men) were analyzed as one group, by means of the Fisher t for small sample correlated means. The only significant difference between means was found to be the slowing down of the free stylers by .37 seconds after calisthenics warm-up as compared with times done after no warm-up. This difference between means was significant at the 5 percent level of confidence.

When the group composed of breaststrokers and dolphin swimmers was analyzed by the Fisher t for small sample correlated means, the only significant difference between means was found to be the improvement of swimming times following calisthenics of 1.52 seconds as compared to no warm-up times. This difference between means was significant approaching the 1 percent level of confidence.

Summary

In an effort to determine the effects of various warm-up procedures upon competitive swimming ability, 13 subjects swam 195 time trials after five different warm-up conditions. The five warm-up conditions were (1) control —no warm-up, (2) swimming 500 yards, (3) six-minute hot shower, (4) calisthenics, and (5) massage. The time trials consisted of a 100-yard swim from a gun start in the swimmer's specialty style.

Analysis of variance by the Type I "mixed" design of Lindquist (13) yielded F ratios which were significant at better than the 1 percent level of confidence for the variance due to warm-up only and for the variance due to the interaction of warm-up and stroke swum.

Further analysis was made using the Fisher t to compare times for the group as a whole, regardless of stroke swum; for the seven free stylers as a group; and for the five breaststrokers and dolphin swimmers as a group.

Major findings were as follows:

1. Considering all swimmers in one group regardless of stroke swum, it was found that warming up by swimming 500 yards was effective in reducing the subsequent 100-yard time trial by a mean difference of .44 seconds. This difference in times was found to be statistically significant at the 5 percent level of confidence.

2. Considering all swimmers in one group, regardless of style swum, it was found that warming up by six-minute hot showers, or by calisthenics, or by massage had no effects which were significantly different from those of the controls.

3. Considering the seven free stylers as a group, only the calisthenics warm-up had a significant effect upon subsequent 100-yard time trials. This effect was a slowing down of the speed of swimming compared to controls, by .37 seconds, which was statistically significant at the 5 percent level of confidence.

4. Considering the five breaststrokers and dolphin swimmers as a group, only the calisthenics warm-up had a significant effect upon subsequent 100-yard time trials. This effect was an increase in the speed of swimming by 1.52 seconds, which was statistically significant approaching the 1 percent level of confidence. This portion of the experiment may be thought to have had a control for mindset, in that all five swimmers considered calisthenics to be harmful to their swimming times.

5. A distinct difference in reaction to warming up by calisthenics was observed between the free style swimmers and the breaststrokers and dolphin swimmers. Whereas the breaststrokers and the dolphin men had improved 100-yard time trials by a mean of 1.52 seconds after calisthenics, the free stylers slowed down by .37 seconds after the same warm-up. Both of these mean differences were statistically significant at the 5 percent level of confidence. It was hypothesized that possibly this difference could be attributed to the fact that strength may play a larger part in the breaststroke and dolphin stroke inasmuch as they show greater acceleration-deceleration within the stroke cycle due to the simultaneous recovery of the arms, and the strength factor was reported the only factor significantly improved by warm-up procedures by Burke (4).

Conclusions

Under the conditions and limitations of this experiment it would seem that:

1. Swimming performance at the level of the highly skilled competitive swimmer can be improved by the proper warm-up procedure.

2. Swimming performance at the level of the highly skilled competitive swimmer can be impaired by the improper warm-up procedure.

3. There is an interaction between the warm-up procedure and the type of stroke swum, so that it may be well to vary the warm-up procedure according to the stroke swum.

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(Submitted 6/9/58)

Reliability, Measurement Error, and Intra-Individual Difference

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Abstract

It is shown that the conventional test-retest reliability coefficient is equal to the "true score" variance divided by the total variance. The former is *inter*-individual variance, measuring true individual differences; the latter is the sum of three components—*inter*-individual variance, *intra*-individual variance, and error of measurement. Using typical reaction and movement time data, it was found that the measurement error variance, using the hundredths second timer, was only 3 to 4 percent as large as the intra-individual variance and had little influence on the reliability coefficient. Measurement error is a characteristic of the test; it may or may not be large enough to reduce the reliability coefficient appreciably. Variations between and within individuals characterize *behavior*, which may or may not be reliable regardless of measurement error.

CONFUSION EXISTS concerning the meaning of the reliability coefficient. It is usually thought of as a measure of the reliability of the *test*, whereas it is in fact a measure of the ratio of individual differences to total variation in test scores (1). Total variation includes individual differences, intra-individual differences, and measurement error. This concept is of considerable importance, since it is basic to proper choice of instruments used to measure neuromotor and muscular behavior. Data recently obtained by Wilson in a study of reaction time and movement, reported in a separate article (3), offer an excellent opportunity to unravel the factors involved.

Reliability

The formula for the reliability coefficient, as it is used in test-retest estimates, is usually some variation of the form:

$$r = \frac{\sigma_a^2 + \sigma_b^2 - \sigma_{a\text{-}b}^2}{2\,\sigma_a\,\sigma_b} \qquad [1]$$

The terms in this expression involve several sources of variance. Consider σ_a^2; it contains, as one component, the "true" individual difference variance σ_t^2 which consists of the variation between individuals that would be observed if an infinite number of scores for each individual were pooled, so that variations *within* the subject, as well as variable *errors of measurement*, would be averaged out and disappear. The second component is the variance due to changes within the individual as well as variations in his response to the test situation. (Ordinarily these two cannot be separated.) This component can be labeled σ_i^2. The third component is the experimental

error, including both errors of observation and variable errors in the instrument itself. This one may be labeled σ_e^2. Since these components are by their nature uncorrelated, we may write:

$$\sigma_a^2 = \sigma_{t_a}^2 + \sigma_i^2 + \sigma_e^2 \text{ and } \sigma_b^2 = \sigma_{t_b}^2 + \sigma_i^2 + \sigma_e^2 \qquad [2]$$

Measurement Error

If we wish to evaluate the error in measurement in an experiment such as Wilson's, the two chronoscopes he used can be connected together and used to make duplicate determinations of each reaction time that is measured. In this case, both σ_t^2 and σ_i^2 are excluded. Since the two instruments have independent mechanisms, their errors are necessarily uncorrelated, and the error variance of one of the instruments, σ_e^2, is equal to half of σ_d^2 computed from the distribution of differences in instrument readings. This assumes, of course, that the errors of the instruments are equal.

Actually, it requires three instruments to determine the error of each single instrument. The two Wilson chronographs and an additional one, all in parallel, were used to secure 275 reaction time measurements. For 1 and 3, σ_d^2 was .8600 (in hundredths of a second); for 2 and 3, it was .8276, and for 1 and 2 it was .9260. Solving with simultaneous linear equations (which is possible because the error variances are additive for any two instruments), σ_e^2 is .4792 for the first Wilson instrument and .4468 for the second. It happens that the errors of these two instruments do not differ significantly, since the F-ratio of the variances is only 1.07 compared with 1.21 required for statistical significance at the 5 percent level. The average of the two, namely .4630, may therefore be taken as the most dependable estimate of σ_e^2.

Intra-Individual Variance

Wilson has made his raw data available to the writer. He found that the averages of 35 trials per subject for movement times with (a) rhythmic and (b) non-rhythmic stimuli correlated $r = .962$. While the conditions were slightly different for *a* and *b* (as indeed is necessarily true in any test-retest situation with living subjects), the two sets of scores agree within the limits of sampling error ($t = 1.33$). The correlation between them may therefore be treated for the present purpose as a test-retest reliability coefficient. The variance of the differences in individual mean scores (σ_{a-b}^2) was .6225 (in hundredths of a second). Now this statistic involves the difference between *two* sets of data, so the variance of a single set is only half as large, namely .3113.[1]

In order to estimate σ_i^2, it is necessary to subtract from .3113 the influence of the measurement error. Since each subject was measured 35 times under

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[1]The writer wishes to call attention to a typographical error in Formula 7 of another article (1). The term σ^2_e was there used to include both σ^2_i and σ^2_e and appeared to equal $\sigma^2_{I\text{-}II}$ as printed, instead of $\sigma^2_{I\text{-}II}/2$. The correct formula is: $r = 1 - \dfrac{\sigma^2_{I\text{-}II}}{2\,\sigma^2_x}$.

both condition *a* and condition *b*, the measurement error for the individual subject means ($\sigma_{e_m}^2$) would be $\sigma_e^2/35$, which is computed as .4630/35 or .0132. Subtracting this from ½ σ_{a-b}^2 yields .2981 as the value for σ_i^2.

There are two possible estimates of σ_t^2, as shown by Equation 2. From the Wilson data, $\sigma_a^2 = 7.9524$ and $\sigma_b^2 = 8.2944$. After subtraction of σ_i^2 and $\sigma_{e_m}^2$, we find that $\sigma_{t_a}^2$ is 7.6411 and $\sigma_{t_b}^2$ is 7.9831. Their average (the best estimate of σ_t^2) is 7.8121. The results are, of course, the same if we estimate the total variability (σ_x^2) as the average of σ_a^2 and σ_b^2, and subtract from it σ_i^2 and $\sigma_{e_m}^2$.

Reliability with Measurement Error Eliminated

From the above data, it can be seen that the elimination of measurement error by subtracting $\sigma_{e_m}^2$ will reduce σ_{a-b}^2 to the value .5962 (i.e. 2 σ_i^2), while σ_a^2 and σ_b^2 will become 7.9392 and 8.2812. Substituting in Formula 1, it is found that the reliability coefficient has increased from .962 to .964. This is certainly not an impressive increase. Evidently *intra-individual* variation rather than measurement error was the important factor determining reliability in this case.

Modern statistical texts, Walker and Lev for example (2, p. 298), recognize that the basic concept of the reliability coefficient derives from the expression:

$$r = \frac{\sigma_t^2}{\sigma_x^2} \qquad [3]$$

In the case of a test-retest correlation, computation shows that the numerator of this ratio is the same as the numerator of Formula 1, and the denominators are also identical if σ_x^2 is computed as the *geometric* rather than arithmetic mean of σ_a^2 and σ_b^2. Substituting the numerical values given earlier, this formula yields the same reliability coefficients as those obtained from Equation 1. The influence of error elimination is, however, easier to visualize, since it alters σ_x^2 only.

In order to show that the above results are not unique, the Wilson data on rhythmic movement time have been used to compute the test-retest reliability coefficient defined as the correlation between the first half and second half of the 34 single movements per subject (discarding the first trial to secure an even split). In this case, σ_{a-b}^2 is 1.613, and $\sigma_{e_m}^2$ is $\sigma_e^2/17$ or .0272. From these figures, σ_i^2 is found to be .7793; σ_a^2 and σ_b^2 are 8.970 and 7.731 before the removal of error, but drop to 8.943 and 7.704 after it has been removed. The reliability coefficient is therefore $r = .906$ using the obtained scores, compared with .909 when measurement error has been removed.

Similar computations have been made with the first half and second half of the rhythmic reaction times. Here, σ_{a-b}^2 is found to be 3.168. Now $\sigma_{e_m}^2$ is the same as it was for movement time, so σ_i^2 is 1.557. Before the removal of measurement error, σ_a^2 is 5.312 and σ_b^2 is 4.030; after removal, the figures are 5.285 and 4.003. The reliability coefficient is therefore .667 from the

obtained scores and increases only to .671 when measurement error has been removed.

While of no concern in the present discussion, it is interesting that the reliability is considerably higher for movement time than for reaction time. It may be noted that the experiment was so arranged that movement and reaction times were of equal length (3).

Single Trial Reliability

Computation using two randomly chosen trials per subject from the Wilson data on reaction time yields $\sigma_a^2 = 16.403$, $\sigma_b^2 = 17.306$, and $\sigma_{a-b}^2 = 14.364$. Since we are here dealing with single trials, $\sigma_e^2 = .463$ is the correct value of the measurement error, and $\sigma_i^2 = 6.719$ hundredths of a second. Proceeding as before, $\sigma_{t_a}^2 = 9.221$, $\sigma_{t_b}^2 = 10.124$, and the reliability coefficient is .574 by either formula. When the measurement error variance is removed, the coefficient increases to .589. This is only a small gain, although it is larger than in the other examples. We may, therefore, conclude that measurement error is a minor factor in determining the reliability of even single-score reaction time measures, provided that it is as small as $\pm$ .66 hundredth seconds (i.e., $\sigma_e^2 < .436$). A more extensive sampling of the single trial responses would probably reveal that the single trial reliability is somewhat less than in this example, which would mean that the measurement error is even less important than indicated.

Generalization

The role of measurement error in other tests of interest in our field is largely undetermined. It is clear, however, that in the case of reaction times, and movement times also when they are as variable as reaction times, the major source of unreliability is variation in the response of the individual rather than in error of measurement. Individuals vary as between one another, and also within themselves; both variations are characteristics of behavior that should be distinguished from measurement error, which is a characteristic of the test. These concepts can be applied to any correlation involving individual differences, although the statistics become more complicated in the general case.

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(Submitted 7/23/58)

Theoretical Specifications for the Racing Dive: Optimum Angle of Take-Off[1]

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Abstract

The problem was to investigate the racing dive in swimming in terms of the basic mechanical principles involved. A mathematical expression was developed to describe the time required to dive, glide, and swim the first length of any race. The validity of this formula was found to be very high by comparing actual measured times for 17 subjects with times computed using the formula. Finally, optimum angles of take-off were determined for various personal characteristics and for specific race conditions.

DURING recent years, great strides have been made in the basic sciences, but many authorities in the field of physical education (including athletics) still base their opinions solely on experience and insight. Often this is good enough; sometimes it is the only possible basis for action in such an inexact field. Nevertheless, the information passed on to young people is sometimes needlessly inaccurate. Comparatively few attempts have been made to investigate sports activities in terms of the mechanical principles involved. A few examples have been included with the references (1, 5, 6, 7, 10, 11, 12, 13, 15, 21), although no effort was made here to exhaust this type of literature. The first book pioneering this line of work in physical education was recently written by Bunn (4).

Nature of the Problem

This particular study was undertaken to explore an observation made from a series of motion pictures of the starts of a large number of college swimmers. It was noted that among these highly skilled performers there was little uniformity in the angle of take-off from the starting block. This angle varied from 5 to 22 deg. without any apparent relationship to body build, stroke mechanics, or competitive success. Basic mechanical theory

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[1]Appreciation is expressed to the College of Education at Southern Illinois University for subsidizing this study. Special thanks are also due to the 17 subjects who cooperated in the collection of data. The writer is particularly indebted to Donald Sammons for his original thinking.

indicates, however, that there should be an optimum angle of take-off for each person under any specific set of circumstances.

Consequently, an effort was made to describe this angle in terms of basic physics. A mathematical expression was developed and validated experimentally, and methods for practical applications of the findings have been suggested.

Great care was taken to account for all possible variables. Otherwise, the results could not be applied to the individual performer in his given situation. For example, it is apparent that such things as body build, starting block dimensions, and desired swimming speed are all determining factors in the racing dive. Figure I is a schematic illustration of each of the graphic variables that have been considered. A number of other variables are defined in the text.

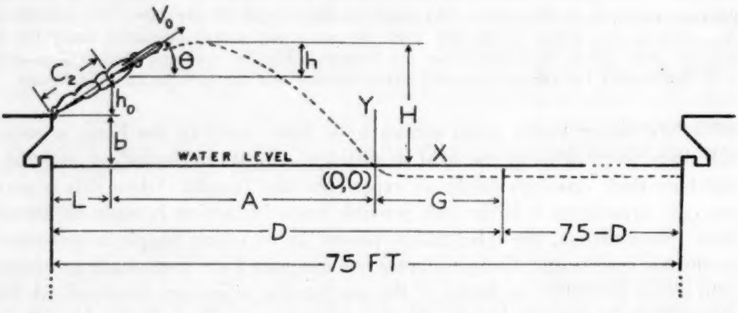

FIGURE I. Schematic illustration of each of the graphic variables that were considered in determining the optimum angle of take-off for swimmers under specific circumstances.

After some preliminary study, the problem resolved itself into one of minimizing the total time, T_T, needed to wind up, dive, glide, and swim one length of a standard 75-ft. pool. The specific angle of take-off, θ, which results in a minimum T_T for a given individual operating within a particular set of circumstances, is referred to as the optimum angle of take-off, θ_p, for that person under the conditions stated. It must be assumed that the swimmer is able to land in a perfectly extended position, has a maximum individual take-off velocity, V_O, and can accurately judge when he is at his desired swimming speed, V_S. These are all reasonable assumptions since it is the optimum angle which is being sought. Armbruster and Morehouse (3) have described the most desirable position for the body during the flight through the air, the entry into the water, and the glide to the surface.

Derivation and Validation of Formula

In order to facilitate the reading of this report, the derivation of the mathematical expression for T_T has been placed in an appendix (see p. 32-36). The final formula is given here as equation 30.[2]

$$T_T = T_L + \frac{V_O \sin\theta}{g} + \sqrt{\frac{V_O^2 \sin^2\theta}{g^2} + \frac{2\,C_2 \sin\theta}{g} + \frac{2\,b}{g}}$$

$$+ \frac{m}{k}\left(\frac{1}{V_S} - \frac{1}{V_O \cos\theta}\right) + \frac{75}{V_S} - \frac{M - C_1}{V_S} - \frac{1}{V_S}\left(C_2 \cos\theta + \frac{m}{k}\log_e \frac{V_O \cos\theta}{V_S}\right.$$

$$\left. + \frac{V_O^2 \sin\theta\cos\theta + V_O \cos\theta\sqrt{V_O^2 \sin^2\theta + 2\,g\,(b + C_2 \sin\theta)}}{g}\right)$$

Although equation 30 looks quite complicated, it is composed of only the following 11 variables: θ, T_L, V_O, g, b, C_2, C_1, m, k, V_S, and M. Each of these can be evaluated in the practical situation.

θ is the angle of take-off in degrees and is the variable in question. For validation purposes, it was measured cinematographically. All pictures were taken directly from the side at 64 frames per sec. The camera was placed over one end of the starting line at the height of the starting block from the water and at a constant distance of 30 ft. from the subject. In using the results of this investigation, optimum values, θ_P, have been computed for individuals having different characteristics.

T_L is the time in seconds spent winding up, leaning, and extending the body until the moment of departure from the starting block. It is dependent primarily upon the characteristics of the individual competitor and the starting block being used and can be measured best by cinematographical techniques.

V_O is the take-off velocity measured in feet per second. It may be approximated for an individual from his maximum vertical jump by using the freely falling body formula,

$$V_O = \sqrt{2\,g\,J},$$

where J is the height of the jump in feet.

g is the constant acceleration due to gravity for any particular locality. It is measured in feet per second per second.

b is the height of the starting block measured in feet.

C_2 is the distance in feet between the swimmer's toes and his center of gravity in an extended position with both of his arms over his head. This may be very closely approximated either by direct measurement or by computation. It has been shown that the center of gravity in the average young male lies at a point which is 57 percent of his standing height above the

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[2]For a breaststroker or a butterfly stroker C_2 will replace C_1 in the equation.

ground (2, 16, 18). A simple allowance of .25 ft. may be made for the depressed feet used in the racing dive. In addition, Cureton and Wickens (9) found that in subjects lying on their backs, the center of gravity moved toward the head an average of another .417 ft. when both arms were stretched overhead. For purposes of this study, the approximation

$$C_2 = .57 \text{ ht.} + .25 + .417$$

or

$$C_2 = .57 \text{ ht.} + .667$$

was used.

C_1, which represents the distance between the swimmer's toes and his center of gravity in an extended position with one of his arms overhead and the other at his side, was computed in a similar fashion except that an allowance of only .208 ft. was made for the one arm being above the head.

m is the mass of the individual in slugs.

k is a constant of drag for the individual in fresh water at normal pool temperatures. According to Klein (14), who used multiple regression techniques with nine measures on 59 subjects, this constant of drag, k, can be estimated by

$$k = -.0122\, G_{10} + .01818 \text{ wt.} - 2.1174,$$

where: G_{10} is the distance in feet that a subject can glide in 10 seconds with the body buoyed to a horizontal position by the use of a streamlined float placed between the legs, and

wt. is the subject's body weight.

The swimmer is instructed to grasp the gutter with one hand and to tuck the body for a front push-off. At a predetermined signal, the subject pushes off as hard as possible, remaining in a prone glide position on the surface of the water throughout the 10-sec. period. The distance used should be the average value of five consistent trials measured to the nearest one-quarter of a foot. Although Klein obtained a multiple coefficient of correlation of only $R = .629$ between his equation and an actual measurement of drag, his results have been found to be the most accurate available. This technique was used in this investigation. At very low body weights, it was found that k must be interpolated.

V_8 is the swimming speed of the individual after the glide in the first length of any given race. V_8 is measured in feet per second. In validating this study, it was measured directly. Three stop watches were used to determine the time spent in the last 45 ft. of each 75-ft. swim. In applying the results of this study, however, desired velocities for different races were used.

M is the maximum height in feet that the individual can reach with one hand while standing on his toes.

In order to validate equation 30, 17 trained university swimmers were asked to swim one length of a standard 75-ft. pool using their normal racing stroke. No backstrokers were included in the sample. Cinematographical

recordings of each start were taken along with official stop watch times for each 75-ft. race. Sufficient additional data were collected on each subject to permit the evaluation of all of the 11 variables in question. A computed time then was worked out from equation 30 and compared with the official time of each swim as measured with stop watches. Table 1 shows the results of this comparison.

In addition, a coefficient of validity, r, was computed between the measured times and the computed times. In spite of the several approximations which had to be made in the evaluation of equation 30, the fact that Subject F just missed his final touch and had to take an additional stroke, that Subject I jumped the gun for a fast start, and that the standard error of stop watch timing is about .1 sec. (8), it was found that

$$r = .975 \pm .013.$$

This represents a very high degree of relationship between the two methods of estimating the true time of a 25-yd. race.

TABLE 1.—COMPARISON OF MEASURED AND COMPUTED TIMES FOR A 25-YD. RACE

Subject	Time Measured with Stop Watches	Time Computed from Equation 30	Measured Minus Computed Discrepancy
A	11.2	11.0	.2
B	14.2	14.5	—.3
C	11.2	11.3	—.1
D	12.1	12.2	—.1
E	12.0	11.9	.1
F[a]	13.3	12.7	.6
G	13.4	13.5	—.1
H	14.8	14.5	.3
I[b]	12.1	12.8	—.7
J	14.1	13.9	.2
K	13.0	13.0	.0
L	11.8	11.6	.2
M	11.8	11.9	—.1
N	13.2	13.2	.0
O	14.7	14.9	—.2
P	11.9	11.9	.0
Q	11.1	11.0	.1

[a] Subject F just missed his final touch and had to take an additional stroke.
[b] Subject I jumped the gun for a fast start.

Application of Results

If one were to take the derivative of T_T with respect to θ in equation 30, by setting

$$\frac{dT_T}{d\theta} = 0$$

one might solve for the optimum angle of take-off, θ_P, which would minimize T_T for any given individual in a particular situation (20, p. 84). Due to the complex nature of equation 30, this is not feasible. Consequently, the task of finding θ_P becomes one of solving the equation for successive values of θ (to the nearest whole degree) until a minimum T_T results. Obviously, this is not a satisfactory procedure for the typical swimming coach with many men and little time.

In order to put the results of this investigation into a usable form which also would permit individual application, reasonable minimum, average, and maximum values were determined arbitrarily for each of the factors used in the evaluation of equation 30. The values used in this study are given in Table 2.

TABLE 2.—MINIMUM, AVERAGE, AND MAXIMUM VALUES OF THE VARIABLES USED IN THE EVALUATION OF EQUATION 30

Variable	Minimum	Average	Maximum
b (ft.)	1.5	2.5	2.5
ht. (in.)	64	71	78
M (in.)	82	93	104
wt. (lb.)	110	160	210
J (in.)	14	21	28
G_{10} (ft.)	18	25	32
V_s (ft./sec.)	4.6	5.4	6.2
g (ft./sec.^{2})	32.119	32.152	32.185

Since T_L is practically independent of θ, T_T-T_L is the quantity which must be minimized in order to find θ_P. Using the average values for each of the variables given in Table 2, equation 30 was solved for successive values of θ until a minimal $T_T - T_L$ of 11.6 seconds was found at a θ_P of 13 degrees. That is, the average competitor under normal conditions, as defined in Table 2, which should dive at an angle of 13 deg. (see Table 3).

Minimum and maximum values for each of the variables then were substituted into equation 30 one by one and corresponding values of θ_P were determined. The results of these computations are given in Table 3. It can be seen that fluctuations within the normal range of all of the variables except g do affect θ_P. These effects were shown to be additive by substituting all values tending to increase θ_P into equation 30 at the same time. Under these conditions, θ_P is 21 deg. Similarly, all values tending to reduce θ_P were used together and produced a value of 6 deg.

Finally, in order to determine what effect diving at the wrong angle would have on a swimmer's time, $T_T - T_L$ was computed at take-off angles of 22 and 5 deg. using average values for all of the other variables.[3] In the case

[3] These values for θ were chosen since they represent the range of take-off angles previously observed in motion pictures.

of $\theta = 22$ deg., T_T-T_L was 11.7 sec. or .1 sec. slower than at θ_P. At $\theta = 5$ deg., T_T-T_L was very nearly though not quite 11.7 sec. (See Table 3.) Although at first these differences may not appear to be great, swimming coaches know that frequently several men finish a race within the interval of .1 sec. Furthermore, this difference was computed for the average competitor. With an unfortunate combination of variables, it could be as great as .2 sec.

TABLE 3.—OPTIMUM ANGLES OF TAKE-OFF, θ_P, AND TIMES REQUIRED TO DIVE, GLIDE, AND SWIM ONE LENGTH OF A 25-YD. POOL AFTER THE TOES LEAVE THE STARTING BLOCK, T_T–T_L, UNDER VARIOUS CONDITIONS OF EQUATION 30

Conditions	θ_P (deg.)	T_T—T_L (sec.) at θ Shown
All variables average	13	11.6
All variables average except $b = 1.5$ ft.	14	11.7
All variables average except ht. = 78 in., $M = 104$ in.	13	11.4
All variables average except ht. = 64 in., $M = 82$ in.	14	11.8
All variables average except wt. = 110 lb.	11	11.4
All variables average except wt. = 210 lb.	15	11.8
All variables average except $J = 14$ in.	10	12.0
All variables average except $J = 28$ in.	15	11.3
All variables average except $G_{10} = 32$ ft.	12	11.5
All variables average except $G_{10} = 18$ ft.	14	11.7
All variables average except $V_S = 6.2$ ft./sec.	12	10.3
All variables average except $V_S = 4.6$ ft./sec.	14	13.4
All variables average except $g = 32.185$ ft./sec.^{2}	13	11.6
All variables average except $g = 32.119$ ft./sec.^{2}	13	11.6
$b = 1.5$ ft., ht. = 64 in., $M = 82$ in., $G_{10} = 18$ ft., wt. = 210 lb., $J = 28$ in., $V_S = 4.6$ ft./sec.	21	13.6
$b = 2.5$ ft., ht. = 78 in., $M = 104$ in., $G_{10} = 32$ ft., wt. = 110 lb., $J = 14$ in., $V_S = 6.2$ ft./sec.	6	10.4
All variables average except $\theta = 22$ deg.		11.7
All variables average except $\theta = 5$ deg.		11.6

Conclusions

The mathematical expression which was developed as a part of this investigation represents a highly valid method of estimating the true time of a 25-yd. swimming race. The correctness of the following statements is based upon the accuracy of this formula:

1. The optimum angle of take-off, θ_P, for the average competitor under normal conditions, as defined in Table 2, is 13 deg.
2. Lowering the height of the starting block from 2.5 ft. to 1.5 ft. increases θ_P to 14 deg. and increases the time of a 25-yd. race by .1 sec.
3. If all other variables remain constant, decreasing height from 71 in. to 64 in. increases θ_P by 1 deg.

4. With identical other characteristics, a tall man can swim 25 yd. faster than a short man.

5. If all other variables remain constant, decreasing weight from 160 lb. to 110 lb. lowers θ_P by 2 deg. Similarly, increasing weight to 210 lb. raises θ_P by 2 deg.

6. With identical other characteristics, a light man can swim 25 yd. faster than a heavy man.

7. If all other variables remain constant, increasing vertical jumping ability from 21 in. to 28 in. raises θ_P by 2 deg. Similarly, decreasing vertical jumping ability to 14 in. lowers θ_P by 3 deg.

8. With identical other characteristics, a man with good vertical jumping ability can swim 25 yd. faster than a man with poor ability.

9. If all other variables remain constant, increasing the distance that a subject can glide on the surface of the water in 10 sec. from 25 ft. to 32 ft. lowers θ_P by 1 deg. Similarly, decreasing 10-sec. glide distance to 18 ft. raises θ_P by 1 deg.

10. With identical other characteristics, a man with good gliding ability can swim 25 yd. faster than a man with poor ability.

11. If all other variables remain constant, increasing swimming speed after the dive and glide from 5.4 ft./sec. to 6.2 ft./sec. lowers θ_P by 1 deg. Similarly, decreasing swimming speed to 4.6 ft./sec. raises θ_P by 1 deg.

12. The variations found in the acceleration due to gravity within the continental United States do not affect either θ_P or the time required to swim 25 yd.

13. The changes which occur in θ_P and in the time of a 25-yd. race due to fluctuations in the variables of equation 30 are additive. Probable maximal and minimal values for θ_P under extreme conditions are 21 and 6 deg.

14. An angular deviation of less than 9 deg. from θ_P will not affect a swimmer's time by an amount which is measurable with a .1 sec. stop watch. Since several men often finish a race within an interval of .1 sec., however, any deviation could be costly in close competition.

Appendix

Derivation of Formula

It is obvious that the total time needed to wind up, dive, glide, and swim one length of a pool may be expressed by the equation

(*1*) $T_T = T_L + T_A + T_G + T_S$,

where: T_L is the time spent winding up, leaning, and extending the body until the moment at which the toes leave the starting block;

T_A is the time spent in the air;

T_G is the time spent gliding; and

T_S is the time spent swimming after the glide.

Although T_L is of great coaching importance and should be minimized, it is chiefly a function of the reaction time and form of the individual and of the condition of the starting block. Cureton (7) studied the duration of T_L with five different abrasive surfaces and found considerable variations. For this analysis, however, T_L need not be evaluated since it is practically independent of θ.

The value of T_A may be computed from

(2) $T_A = T_h + T_H$,

where: T_h is the time required for the swimmer's center of gravity to reach the highest point of his dive, and

T_H is the time required for the swimmer's center of gravity to fall back to water level from height H.

From the laws pertaining to the flight of a projectile (17, p. 22), one can see that

$$(3) \quad T_h = \frac{V_0 \sin \theta}{g},$$

where: g is the acceleration due to gravity for any particular locality, and

V_0 is the take-off velocity.

Next, using the standard falling body formula (17, p. 20)

$$H = \tfrac{1}{2}\, g\, T_H^2,$$

it can be shown that

$$(4) \quad T_H = \sqrt{\frac{2\,H}{g}}.$$

However, from Figure I

(5) $H = h + h_0 + b$,

where: h is the distance that the swimmer's center of gravity rises between the take-off and the top of the dive,

h_0 is the height of the swimmer's center of gravity above the starting block at the moment of take-off, and

b is the height of the starting block.

One can see that

(6) $h_0 = C_2 \sin \theta$,

where: C_2 is the distance between the swimmer's toes and his center of gravity in an extended position with both of his arms over his head.

According to the formula for the height of the path of a projectile (17, p. 22)

$$(7) \quad h = \frac{V_0^2 \sin^2 \theta}{2\,g}.$$

Substituting equations (6) and (7) into (5) yields

$$H = \frac{V_0^2 \sin^2 \theta}{2\,g} + C_2 \sin \theta + b.$$

With this value for H, equation (4) takes the form

$$(8) \quad T_H = \sqrt{\frac{V_0^2 \sin^2 \theta}{g^2} + \frac{2C_2 \sin \theta}{g} + \frac{2\,b}{g}}.$$

Finally, substituting (3) and (8) into (2) gives

$$(9) \quad T_A = \frac{V_0 \sin \theta}{g} + \sqrt{\frac{V_0^2 \sin^2 \theta}{g^2} + \frac{2C_2 \sin \theta}{g} + \frac{2\,b}{g}}.$$

In order to compute T_G, one must note that during the glide there is a force, F, commonly called drag, which is acting in a direction negative to the horizontal movement of the swimmer. According to Rouse (19) this is defined for a body in water as

(10) $F = -\tfrac{1}{2}\, Q\, B\, q\, V_x^2$,

where: Q is the coefficient of drag of the body,

B is the cross-sectional area of the body,

q is the density of the water, and

V_x is the horizontal velocity of the body.

In order for equation (*10*) to apply to a human body, the swimmer must land flat in an extended position. As this is considered to be good form, the assumption is justified in the search for an optimum angle of take-off. Only a slight error is encountered at this point by neglecting the wave action set up when the swimmer hits the water. Practically nothing is known about this phenomenon. Since Q, B, and q are all constants for a given person in fresh water at normal pool temperatures, equation (*10*) may be rewritten as

$$(11)\quad F = -k\ V_x^2,$$

where: k is a constant of drag for the individual under standard conditions.

According to Newton's second law of motion (17, p. 44) any force may be represented by

$$(12)\quad F = m\ a = m\frac{dv}{dt},$$

where: $m = \text{mass or } \dfrac{\text{weight}}{g}$, and

$a = \dfrac{dv}{dt}$ is the acceleration of the body in terms of the derivative of the velocity, v, with respect to the time, t, (20, p. 106).

Substituting (*12*) into (*11*) yields

$$(13)\quad \frac{dV_x}{dt} = -\frac{k}{m} V_x^2.$$

This can be written in integral form as

$$\int \frac{dV_x}{V_x^2} = -\frac{k}{m}\int dt.$$

Upon integrating,

$$(14)\quad -\frac{1}{V_x} = -\frac{k}{m} t + K_1.$$

To evaluate the constant of integration, K_1, one substitutes the values of t and V_x, at the time of contact with the water, into equation (*14*). At that moment, since the drag has had no chance to operate if one neglects air resistance, one may define

$$t = O.$$

Similarly, V_x will be identical to the horizontal component of velocity upon take-off. That is,

$$V_x = V_o \cos\theta.$$

Equation (*14*) now becomes

$$(15)\quad -\frac{1}{V_o \cos\theta} = K_1.$$

Substituting (*15*) into (*14*) yields the general equation

$$(16)\quad \frac{1}{V_x} = \frac{k}{m} t + \frac{1}{V_o \cos\theta}.$$

At the end of the glide,

$$t = T_o$$

and

$V_x = V_s$, the desired swimming speed.

Therefore, equation (*16*) becomes

$$(17)\quad \frac{1}{V_s} = \frac{k}{m} T_o + \frac{1}{V_o \cos\theta}.$$

Finally, solving *(17)* for T_G results in

$$(18)\quad T_G = \frac{m}{k}\left(\frac{1}{V_s} - \frac{1}{V_0 \cos\theta}\right).$$

The only member of the right-hand side of equation *(1)* which has not been accounted for is T_s. From the standard relationship for the distance, s, traveled in a time, t, at velocity, v, which is

$$s = v\,t,$$

one can see that for a freestyler in a 75-ft. pool,

$$(19)\quad T_s = \frac{75 - D - (M - C_1)}{V_s},$$

where: D is the distance of the lean, dive, and glide,
M is the maximum height that the subject can reach with one hand while standing on his toes, and
C_1 is the distance between the swimmer's toes and his center of gravity in an extended position with one of his arms over his head and the other at his side. For a breaststroker or butterfly stroker C_3 will replace C_1.

But,

$$(20)\quad D = L + A + G,$$

where: L is the distance that the swimmer leans,
A is the distance that the swimmer travels in the air, and
G is the distance that the swimmer glides.

One can see immediately from Figure I that

$$(21)\quad L = C_2 \cos\theta.$$

Furthermore, the standard formula for A (4, p. 263) is

$$(22)\quad A = \frac{V_0^2 \sin\theta \cos\theta + V_0 \cos\theta \sqrt{V_0^2 \sin^2\theta + 2\,g\,(b + C_2 \sin\theta)}}{g}.$$

The easiest way to find G is to make use of equation *(13)*. According to differential calculus (20, p. 234),

$$\frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = v\frac{dv}{dx}.$$

Therefore, equation *(13)* may be rewritten as

$$V_x \frac{dV_x}{dX} = -\frac{k}{m} V_x^2.$$

Putting this into integral form yields

$$\int \frac{dV_x}{V_x} = -\frac{k}{m}\int dX.$$

Upon integrating,

$$(23)\quad \log_e V_x = -\frac{k}{m} X + K_2,$$

where: $\log_e V_x$ means the logarithm to the base e of V_x.

To evaluate the constant of integration, K_2, one substitutes the values of X and V_x, at the time of contact with the water, into equation *(23)*.

Since at that moment

$$X = 0$$

and, neglecting air resistance

$$V_x = V_0 \cos\theta,$$

equation (*23*) becomes

$$(24) \quad \log_e V_o \cos \theta) = K_2.$$

Substituting (*24*) into (*23*) yields the general equation

$$(25) \quad \log_e V_X = -\frac{k}{m} X + \log_e (V_O \cos \theta).$$

At the end of the glide,

$$X = G$$

and

$$V_X = V_S.$$

Therefore, equation (*25*) becomes

$$(26) \quad \log_e V_S = -\frac{k}{m} G + \log_e (V_O \cos \theta).$$

Then, solving (*26*) for G results in

$$(27) \quad G = \frac{m}{k} \log_e \frac{V_O \cos \theta}{V_S}.$$

Now substituting equations (*21*), (*22*), and (*27*) into (*20*) yields

$$(28) \quad D = C_2 \cos \theta + \frac{m}{k} \log_e \frac{V_O \cos \theta}{V_S} + \frac{V_O^2 \sin \theta \cos \theta + V_O \cos \theta \sqrt{V_O^2 \sin^2 \theta + 2\,g\,(b + C_2 \sin \theta)}}{g}.$$

Upon substituting equation (*28*) into equation (*19*) one gets

$$(29) \quad T_S = \frac{75}{V_S} - \frac{M - C_1}{V_S} - \frac{1}{V_S}\left(C_2 \cos \theta + \frac{m}{k} \log_e \frac{V_O \cos \theta}{V_S} + \frac{V_O^2 \sin \theta \cos \theta + V_O \cos \theta \sqrt{V_O^2 \sin^2 \theta + 2\,g\,(b + C_2 \sin \theta)}}{g} \right).$$

Finally, in order to find T_T, one substitutes equations (*9*), (*18*), and (*29*) into equation (*1*), which results in

$$(30) \quad T_T = T_L + \frac{V_O \sin \theta}{g} + \sqrt{\frac{V_O^2 \sin^2 \theta}{g^2} + \frac{2 C_2 \sin \theta}{g} + \frac{2\,b}{g}} + \frac{m}{k}\left(\frac{1}{V_S} - \frac{1}{V_O \cos \theta} \right) + \frac{75}{V_S} - \frac{M - C_1}{V_S} - \frac{1}{V_S}\left(C_2 \cos \theta + \frac{m}{k} \log_e \frac{V_O \cos \theta}{V_S} + \frac{V_O^2 \sin \theta \cos \theta + V_O \cos \theta \sqrt{V_O^2 \sin^2 \theta + 2\,g\,(b + C_2 \sin \theta)}}{g} \right).$$

For a breaststroker or a butterfly stroker C_2 will replace C_1 in both equation (*29*) and (*30*).

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Prediction of Baseball Ability through an Analysis of Measures of Strength and Structure[1]

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Abstract

The purpose of this study was to determine the relation of 19 selected structural and strength measures to success in the baseball skills of hitting, running, throwing, and fielding plus over-all baseball ability. The structural measures tested have consistently low correlations with the criteria. The measures of strength tested have consistently high correlations with the criteria: .79, left shoulder flexion with hitting; .72, right shoulder flexion with throwing; and .67, left shoulder flexion with total ability. Left shoulder flexion is the best single measure found to predict baseball ability. Right shoulder flexion ranks second.

MANY FACTORS contribute directly or indirectly to a proficient baseball performance. If each of these factors could be isolated and measured the sum of these measurements should indicate the type of individual who will succeed or fail in the game of baseball. However, the very nature of many of the factors plus the problems involved in experimental work make the discovery of such an individual most difficult.

Of the factors involved in the ability to succeed in baseball, two of the most important are body structure and muscular strength. There has been a great deal of reflective judgment but very little scientific research to aid in understanding the relative importance of these factors.

The purpose of this study was to determine the relation of selected structural and strength measures to success in the baseball skills of hitting, running, throwing, and fielding and to ascertain if there are patterns or combinations of these measures which can be used to predict success in each skill in addition to over-all baseball ability.

Procedure

The subjects used for this study were 56 men participating in the freshman physical education classes at Wake Forest College. This group represented all

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[1]This study was carried out in partial fulfillment of the requirements for the Doctor of Education degree in the School of Education, George Peabody College, under the direction of Dr. Solon B. Sudduth.

of the freshmen taking part in physical education at the ten o'clock hour on Monday, Wednesday, and Friday. There was no method of classification in assigning the students to this hour except scheduling convenience.

VARIABLES

Measures of structure and strength were selected on the basis of suggestions from college baseball coaches, professional scouts, and related literature. Eight structural measurements were chosen which might have a close relation to baseball ability and which possibly could be increased through exercise and conditioning. The 11 strength measures chosen were considered as those most closely related to the performance of baseball skills. The 19 items measured are listed below:

1. Height
2. Weight
3. Arm span
4. Upper arm girth
5. Chest circumference
6. Hip circumference
7. Thigh circumference
8. Calf circumference
9. Right hand grip
10. Left hand grip
11. Right wrist flexion
12. Left wrist flexion
13. Right elbow flexion
14. Left elbow flexion
15. Right shoulder flexion
16. Left shoulder flexion
17. Hip extension
18. Knee extension
19. Ankle plantar flexion

Structural measurements taken in this investigation were taken according to frequently used procedures in physical education testing programs. Grip strengths were taken by using a hand dynamometer. All other muscle groups were measured by using two aircraft tensiometers, one with a range of zero to 200 pounds and the other with a range of 100 to 400 pounds. These measurements were taken in accordance with techniques developed by Clarke (1). In recording the structural and strength items the subject was always given two tries and only his better score was recorded. Each test was administered on a test re-test basis with the two administrations usually coming two days apart.

CRITERIA

The second phase of the study was to select or design and administer tests of the five criteria: hitting, running, throwing, fielding, and total ability in baseball.

1. *Hitting.* The subject was asked to step into the batter's box and to hit balls pitched by an automatic pitching machine until he was told to stop. Three experts stood behind and to the right of the batter's box and each rated the subject on the rating sheet designed and provided by the writer. The score was the sum of the three experts' rating sheets.

2. *Running.* A home to second base run was used. Using the start recommended for stealing bases the timing started at the first reaction of the subject

to the word "go." The subject was required to touch first and second base. The score was the elapsed time, measured to the nearest tenth of a second, which was needed to run from home plate to first base to second base. The better of two trials was accepted.

3. *Throwing.* The baseball throw for distance was used. The subject took a short run and threw the ball as far as possible. The score was the best of three throws measured to the nearest yard.

4. *Fielding.* A ball toss test, a ball pick-up test, and a test of catching fly balls were chosen. In the ball toss test the subject took a starting position directly beneath a rope stretched at a ten foot height. On the signal to start he tossed the ball over the rope and caught it. He continued to do so as many times as possible in 30 seconds. The score was the number of times the ball was tossed over the rope in this period of time.

In the ball pick-up test the tester stood at the vertex of a 90° angle, the sides of which extended 8½ feet. The subject took a crouched position between the two lines facing the tester. On the signal to start, the tester rolled a baseball down one side of the angle and the subject caught it at the end of the line and tossed it back. The tester rolled a second ball down the other line of the angle and the subject caught this one at the end of the line and returned it. He continued to return the ball as many times as possible in 30 seconds.

In the test of catching fly balls, the subject took a starting position on a line 60 yards from the tester. Eight fly balls were hit to the subject in succession. He was told to catch them, if possible, on the fly and toss them to a student assistant. He was told to make an effort to catch every ball hit except ground balls. The score was the number of balls caught on the fly.

The score for the fielding criterion was the total of the three tests.

5. *Total Ability.* The score for this criterion was determined by averaging the T-scores of the other four criteria.

Analysis of Data

The reliability of each test item was first computed. The raw scores were then converted to T-scores, and the inter-correlations were obtained with the aid of an IBM machine. A cluster analysis was made to aid in grouping the test items, and multiple correlations were computed on the basis of these groupings. It was then possible to develop multiple regression equations for the purposes of predicting the criteria.

Reliability coefficients were computed by correlating the scores of a first and second test for each item using the Pearson Product-Moment Method (2). Table 1 shows the result of these correlations for the criteria scores.

The raw scores for each item were converted into T-scores to make certain that the scores on all the measures were normally distributed. A method outlined by Walker (4) was employed.

TABLE 1.—RELIABILITY COEFFICIENTS OF CRITERIA ITEMS

Criteria Item	r
Hitting	.955
Running	.829
Throwing	.961
Fielding	.925

TABLE 2.—CORRELATION OF CRITERIA WITH TEST ITEMS, GROUPED ACCORDING TO CLUSTER ANALYSIS

Test Item	Hit	Run	Throw	Field	Total Ability
Cluster One					
Weight	(.41)	—.04	.22	.15	.17
Upper Arm Girth	(.50)	.00	(.35)	.20	(.27)
Chest Circum.	(.44)	.05	(.29)	.25	(.28)
Hip Circum.	(.34)	.02	.13	.09	.11
Thigh Circum.	(.30)	—.10	.16	.03	.08
Calf Circum.	.18	—.14	.04	.00	—.01
Cluster Two					
Height	—.06	.11	.03	.07	.03
Arm Span	—.05	.10	.03	.04	.01
Cluster Three					
R. Wrist Flex.	(.66)	(.29)	(.66)	(.49)	(.56)
L. Wrist Flex.	(.60)	(.40)	(.57)	(.47)	(.53)
R. Elbow Flex.	(.54)	(.28)	(.53)	(.48)	(.51)
L. Elbow Flex.	(.45)	.18	(.48)	(.32)	(.36)
R. Shoulder Flex.	(.68)	.24	(.72)	(.45)	(.55)
L. Shoulder Flex.	(.79)	(.38)	(.73)	(.54)	(.67)
Hip Extension	(.60)	.24	(.45)	(.40)	(.48)
Knee Extension	(.52)	(.34)	(.58)	(.44)	(.53)
Ankle Pl. Flex.	(.45)	.15	(.34)	.24	(.30)
Cluster Four					
Right Hand Grip	(.32)	.16	.26	.23	.22
Left Hand Grip	(.36)	.18	(.38)	(.28)	(.27)

( ) denote significant correlations.

The correlation of each measure of structure and strength with each criterion was tested for significance at the .05 level. Using 56 subjects the .05 level of significance with N-2 degrees of freedom (54) is .264. The measures of structure and strength that attained this significant correlation with the criteria are shown in Table 2.

An examination of the correlation matrix revealed a large number of items that are highly correlated with the criteria. These items also have comparatively high correlations with each other. Since it was suspected that many of these items measured similar factors, a cluster analysis technique was employed to aid in the grouping of test items. The method of cluster analysis used for this study was Tryon's modification of Holzinger and Harman's (3)

B-coefficient. Four distinct clusters which appear to measure different characteristics of body structure and strength are shown in Table 2.

The multiple correlations were selected for computation on the basis of the groupings in the cluster analysis. The item in each cluster which correlated highest with the criterion being considered was selected. Multiple correlations were computed for all possible combinations of the selected items with the five criteria. The .05 level of significance was found to be .328. The method devised by Wren (5) was used to compute the multiple correlations.

On the basis of the multiple correlations, multiple regression equations were computed in raw score form for each criterion. The largest difference in multiple correlations using a combination of either four or two variables with any one of the five criteria was only .014. Since a decrease of this size was not considered significant, it was determined to formulate a two-item equation for each of the criteria. In each case the two items selected had the highest multiple correlation with the particular criterion. Table 3 shows the best predictive measures for each criterion and Table 4 shows the regression equation for each criterion.

TABLE 3.—BEST PREDICTIVE MEASURES FOR EACH CRITERION

Criterion	Best Single Measure	Best Combination of Measures
Hitting	Left shoulder flexion ($r = .79$)	Left shoulder flexion and upper arm girth ($R = .79$)
Running	Left wrist flexion ($r = .40$)	Left wrist flexion and height ($R = .42$)
Throwing	Left shoulder flexion ($r = .73$)	Left shoulder flexion and height ($R = .75$)
Fielding	Left shoulder flexion ($r = .54$)	Left shoulder flexion and height ($R = .56$)
Total Ability	Left shoulder flexion ($r = .67$)	Left shoulder flexion and height ($R = .69$)

TABLE 4.—TWO-ITEM BATTERIES AND PERCENT OF VARIANCE FOR PREDICTION OF EACH CRITERION

Criterion	Regression Equation	% of Variance
Hitting	X_1 = .58 (upper arm girth) + .43 (left shoulder flexion) — 15.24	62.38
Running	X_2 = .03 (height) + .02 (left wrist flexion — 5.14	17.87
Throwing	X_3 = 1.08 (height) + .59 (left shoulder flexion) — 64.55	55.96
Fielding	X_4 = .60 (height) + .24 (left shoulder flexion) — 8.68	31.81
Total Ability	X_5 = .50 (height) + .28 (left shoulder flexion) — 15.15	47.07

Conclusions

The results of this study are as follows:

1. The measures of strength tested have consistently high correlations with the criteria. Left shoulder flexion has a high correlation with each criterion and is the best single measure found in this study to predict baseball ability. Right shoulder flexion ranks second.
2. The measures of structure have low correlations with the criteria and their contributions to the predictive equations are generally insignificant.

Recommendations

The following recommendations for further study are made:

1. Each of the four fundamental skills of baseball investigated in this study needs further investigation. Especially needed is a more detailed study of hitting and throwing, treating those individuals who throw left-handed separately from those who throw right-handed and those who bat left-handed separately from those who bat right-handed.
2. Since the measures of structure added little to the predictive equations in this study, it is probable that a more valid prediction of baseball ability could be developed by combining the most pertinent strength factors with other contributing factors, i.e., depth perception, agility, and hand-eye coordination.
3. Grip strength is often associated with success in hitting. The comparatively low correlations between grip strength and hitting ability ($r = .32$) found in this study indicate the need for further research in this area.

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Self-Attitudes of Women Physical Education Major Students and of Women Physical Education Teachers[1]

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Abstract

The purpose of this study was to determine the relationship between the self-attitudes of women physical education major students and those of women physical education teachers. Subjects used in the study were 277 women physical education major students from three institutions and 167 women physical education teachers. The "Who Am I?" test, a Twenty Statements Test of Self-Attitudes (TST), was used as a measure of self-attitudes. The results of this study indicated that there was a significant difference beween the self-attitudes of student groups within a school and between schools. It was also indicated that the self-attitudes of teachers differed significantly from those of students enrolled in a liberal arts college or a teachers college connected with a university but were similar to those of students in a teacher education institution.

ONE OF THE MANY PROBLEMS confronting physical educators in the field of teacher education is retention of desirable physical education major students in the teaching field. The challenge of maintaining quality while attempting a balance between supply and demand is ever present. Much thought has been devoted to the many facets of the problem. Some related research has been conducted. A major area which needs to be studied further is counseling and guidance with respect to the recruitment and retention of desirable physical education students in the teaching field.

Recent studies conducted in other fields, investigating the area of self-attitudes and employing the "Who Am I?" test (TST), have indicated that an examination of the self-attitudes of physical education major students would be of invaluable aid to our counseling program. The results obtained from previous use of the TST indicated that individuals responded with characteristic patterns when asked to answer 20 times the question, "Who Am I?" It was further revealed that those students preparing for a particular profession responded with answer patterns characteristic of the specific profession and of the particular level of training.

The TST had not been administered to physical education major groups. It was assumed that the use of this test with this professional group might

[1]This report is taken from the findings of a study conducted under the direction of M. Gladys Scott and submitted as partial fulfillment of the requirements for the Ph.D. degree at the State University of Iowa.

reveal characteristic attitudes which could then be used in the implementation of a more adequate counseling program. If, for example, the majority of freshmen women majors responded with statements indicating a high degree of social dependency, one who deviated from this pattern might possibly need some counseling to determine if she were in the correct field. It also seemed logical to assume that if physical education major students possessed similar attitudes toward self, teachers of physical education would possess and express like responses. It was for these reasons that the present study was undertaken to determine the relationship between self-attitudes of women physical education major students and those of women teachers of physical education.

Review of Literature

Social psychologists within the past 30 years have questioned the earlier organismic orientation, which viewed human behavior and personality as being static and biologically determined. With the aid of new and more precise measurement techniques, they have been able to conduct research in an area previously considered outside the realm of scientific inquiry. The results of such investigations have indicated a more dynamic interpretation of personality as viewed in a biosocial context. Central to this newer symbolic interaction theory is the self.

Despite the belief that the self is the core of this newer concept, it has not been used to any great extent in research. According to Kuhn, one of the most important reasons for this is the lack of consensus concerning the assignment of self to the proper class of phenomena (10, p. 68). Mead's view of the self as having a development seems to be one which is most widely accepted (12). According to this interpretation, in the process of self-development and social experience the individual becomes an object to himself by taking the attitudes of other individuals toward himself within an organized setting of social relationships. This view of the self as an object like any other object, and of an object as a plan of action, permits the classification of the self as an attitude.

"An attitude is a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects with which it is related" (1, p. 50). Young states that attitudes rest upon stimulus-response patterns as these have been modified, elaborated, and integrated through learning in the social world (19). This would seem to indicate that they are learned or conditioned. Attitudes have affective properties of varying degrees which may be due to motivational or nonmotivational sources.

Sherif and Cantril view attitudes as more or less enduring states of readiness (15). The building up of these attitudes is so largely unconscious that we are not aware of how they arose. They do not exist without reference to value meanings. These meanings are related to situations around which habits have been constructed and series of images have been developed.

The classification of the self as a general attitude, according to Kuhn, permits the use of techniques which have been successfully employed in the study of other attitudes (8, p. 44). Many studies have been conducted using the questionnaire method of measuring attitudes. Bugental and Zelen (3) experimented with various sets of questions in an attempt to find a means for quickly eliciting an expression of the individual's manner of viewing himself. As a result of their studies it was revealed that the "Who Are You?" question afforded the most revealing information. This question permitted the respondent to structure his three answers along lines most expressive of his own needs and most meaningfully related to his current situation. The structure of the responses was such that it permitted analysis along lines most consistent with the basic theoretical viewpoint and within a framework suitable for controlled statistical analysis (3, p. 484).

The results of another study by Bugental and Gunning (2), using the W-A-Y technique, indicated that there was a consistency in responses and content categories in terms of the sociological influences. These categories remained stable even when the total responses had been reduced into subdivisions and contrasted in terms of certain sociological dimensions. Similar results were obtained by Kuhn and McPartland (8, 9, 10) in their attempts to measure and identify self-attitudes. The "Who Am I?" test, a Twenty Statements Tests of Self-Attitudes (TST), emerged as the result of various pilot studies which they conducted at the State University of Iowa.

The TST permits 20 answers to the simple question, "Who am I?" A time limit is established for the test to assure spontaneous and unstructured responses. In answering the question, as if to himself, "the respondent's statements become the items of the test and whatever scales are possible are those which emerge from a content classification of these items after they have been made" (9, p. 1).

McPartland administered the TST to 288 subjects. Their responses were analyzed and dichotomously categorized. The content categories used "distinguish between statements which refer to groups and classes whose limits and conditions of membership are matters of common knowledge, i.e., *consensual;* and those which refer to groups, classes, attributes, traits, or any other matters which would require interpretation by the respondent to be precise or to place him relative to other people, i.e., *subconsensual*" (11, p. 32). From the sequence of responses on the page it was revealed that the respondents tended to give all of the consensual references before they made any subconsensual ones, if any. This ordering of responses seemed to be evident regardless of the number of subconsensual references. The number of references either consensual or subconsensual made by the respondents varied from 20 to none. The number of consensual references given before the subconsensual statements, Kuhn and McPartland termed *locus score,* or the degree of social anchorage (10, p. 70).

The results of the preliminary investigations of the "Who Am I?" test indicated that the self possessed organization, persistency, and predictiveness. It was also revealed that these traits could be measured according to acceptable scientific standards. Many other studies have been conducted employing this test. Stewart (16), Waisanen (18), Mulford (14), Couch (4), Holloway (6), Tompkins (17), Hurlburt (7), and Miller (13) each investigated the relationship between self-attitudes and sociological dimensions, as measured by responses to the "Who Am I?" and other aspects of behavior as determined by other testing devices.

Subjects

Two hundred seventy-seven women physical education major students and 167 women physical education teachers served as subjects in this study. One hundred sixty-eight of the participating students were enrolled at Illinois State Normal University, 57 were students at the State University of Iowa, and 52 were students at the University of Nebraska. The author's familiarity with these three institutions was the only basis for selecting these particular groups of women physical education major students.

One hundred seventeen of the participating physical education teachers were contacted by letter. This group was composed of alumnae listed in the State University of Iowa physical education alumnae file and the 1954 graduates of Illinois State Normal University. In both instances, the entire group of alumnae known to be still in the teaching field, a total of 196 teachers, was contacted. The author's immediate access to this information was the only basis for selecting the alumnae of these two schools as subjects. The remaining 50 participating physical education teachers were personally contacted by the investigator.

Procedure

The TST was administered to the women physical education major students of the three participating schools in the fall of 1955. In each situation, the tests were administered in class situations. There was no attempt to administer the tests to those major students not enrolled in these classes. Therefore, the numbers participating as subjects do not represent the total number of majors at each institution. A repeat of the TST was administered in the spring of 1956 to the same group of students from Illinois State Normal University and the University of Nebraska. Staff members of the various institutions administered the test. Instructions concerning the administration were given to each administrator.

The TST was mailed to the 117 physical education teachers. Although instructions were mailed telling how to proceed, there was no assurance that the directions had been followed. The TST had not been used in this manner before. As it requires spontaneous responses, it was deemed essential to contact and administer the test personally to a group of like people in

an effort to substantiate the results of the self-administered TST. Fifty physical education teachers served as subjects for this phase of the project. A questionnaire concerning the number of years of teaching experience was also given to each of the participating teachers.

Locus scores, defined as the degree of social anchorage or the degree of importance of things external to oneself, were computed from the responses to the TST. The method of scoring developed by Kuhn and McPartland was used (10, pp. 68-76). This procedure necessitated interpreting each of the responses on each questionnaire as either consensual, i.e., references to group membership such as girl, student, major in physical education, or subconsensual, i.e., references to groups or feelings whose limits could be identified only by the respondent. Examples of the latter type are a good student, lover of sports, happy individual. The point in the twenty responses at which the respondent ceased giving consensual statements and began making subconsensual references was the numerical representation of social anchorage. This obtained score was referred to as a locus score.

Mean, standard error of the mean, and standard deviation of the locus scores were computed for each group and for each administration. The significance of the differences between means for the various groups and between the two administrations was determined by use of the "t" test (5).

Analysis of Data

The mean locus scores of the groups of teachers and the t values for the significance of the difference between the means are presented in Table 1. As indicated, there is a significant difference between Group IV, those who had taught for 10 years or over, and also between the total teacher groups. Those to whom the TST was administered by the researcher attained a higher mean locus score. Miller (13), who had administered the TST by mail in a study which followed the present one, obtained similar results. It was his contention that personal supervision and the competitiveness in group situations would tend to affect the results and would seem to cause an increased locus score.

TABLE 1.—SUMMARY AND COMPARISON OF MEAN LOCUS SCORES OF TEACHER GROUPS ACCORDING TO YEARS OF EXPERIENCE

	Self Administered				Administered by Researcher				
Group[a]	N	M	S.E.	S.D.	N	M	S.E.	S.D.	t's
I	8	8.57	.29	7.15	3	6.00	2.15	3.04	1.18
II	1[illegible]	7.79	1.28	5.42	13	9.62	1.81	6.26	.83
III	[illegible]	8.61	1.21	6.60	12	9.92	1.86	6.16	.59
IV	[illegible]9	7.44	.75	5.73	22	12.50	1.14	5.26	3.71[b]
All	117	7.90	.55	5.99	50	10.74	.85	5.94	2.81[b]

[a]Group I, One year teaching experience; II, Two to five years experience; III, Six to ten years experience; IV, Over ten years experience.
[b]Significant at 1 percent level of confidence.

Although the difference between the two groups of teachers was significant, there possibly could have been an element of selectivity in the group to which the test was administered by the writer. Members of this group were all college teachers and were contacted, for the most part, at a workshop for physical education teachers. This setting, in a work and vacation area, was different from that of the teachers in a school situation who were experiencing the pressures of their particular jobs.

The means of locus scores for the various groups of students are given in Table 2. Differences within school groups and between groups are apparent (see Table 3). These differences could be due to a number of factors. The structure, cohesiveness, maturity, and background of the group, the location of the school, and the philosophy and type of school are only a few of the possible explanations.

TABLE 2.—SUMMARY OF MEAN LOCUS SCORES OF STUDENT GROUPS ACCORDING TO YEAR AND SCHOOL

	First Administration				Second Administration			
School	N	M	S.E.	S.D.	N	M	S.E.	S.D.
				Senior				
A	21	8.05	1.24	5.56	12	12.83	1.81	6.01
B	14	14.57	1.30	4.69				
C	11	9.73	1.68	5.31	9	10.22	1.22	3.45
All	46	10.43	.89	5.94	21	11.71	1.18	5.27
				Junior				
A	28	7.61	1.11	5.78	23	9.22	1.26	5.95
B	10	13.00	1.45	4.36				
C	9	9.00	2.23	6.31	9	9.11	2.12	6.01
All	47	9.02	.89	6.02	32	9.19	1.08	5.99
				Sophomore				
A	37	8.67	.20	5.81	31	12.42	1.13	6.17
B	15	7.87	1.50	5.60				
C	10	9.40	1.80	5.41	10	14.60	2.67	7.34
All	62	8.60	.73	5.72	41	12.96	1.03	6.54
				Freshman				
A	60	8.85	.74	5.67	48	9.73	.83	5.69
B	18	11.33	1.44	5.94				
C	10	14.60	1.61	4.82	10	11.90	.48	1.45
All	88	10.01	.64	5.97	58	10.10	.70	5.27
				Total				
A	146	8.45	.47	5.69	114	10.68	.57	6.11
B	57	11.51	.78	5.84				
C	40	10.70	.95	5.91	38	11.55	.95	5.80
All	243	9.54	.38	5.93	152	10.90	.48	5.90

School A, Illinois State Normal University; School B, State University of Iowa; School C, University of Nebraska.

TABLE 3.—COMPARISON OF MEAN LOCUS SCORES OF STUDENTS ACCORDING TO YEAR AND SCHOOL, AND OF TOTAL TEACHER GROUP

Group	Senior	Junior	Sophomore	Freshman	Total
School A					
Junior	.26 1.64[a]				
Sophomore	.50 .19	.62 1.89			
Freshman	.55 1.56	.93 .34	.23 1.92		
Total	.30 1.13	.70 1.05	.45 1.37	.45 .95	
School B	3.63[b]	2.95[b]	.54	1.53	3.55[b]
School C	.80 1.20	.56 .04	.40 .75	3.25[b] 2.26[c]	2.12[c] .78
Total Students	1.56 .52	.99 .02	1.04 .35	1.19 .35	1.79 .29
Total Teachers					.76
Test 1 and 2	2.18[c]	.96	3.28[b]	.79	3.00[b]
School B					
Junior	.83				
Sophomore	3.46[b]	2.46[c]			
Freshman	1.71	.81	1.76		
Total	2.10[c]	.90	2.16[c]	.11	
School C	2.28[c]	1.50	.65	1.51	.66
Total Students	2.63[b]	2.34[c]	.44	.84	2.27
Total Teachers					3.78[b]
School C					
Junior	.25 .45				
Sophomore	.13 1.49	.14 1.61			
Freshman	2.10[c] 1.28	2.04 1.28	2.15[c] 1.00		
Total	.50 .86	.70 1.05	.64 1.08	2.09[c] .33	
Total Students	.37 .88	.01 .03	.41 .57	2.65[b] 2.12[c]	1.14 .61
Total Teachers					2.56[c]
Test 1 and 2	.24	.04	1.64	1.61	.63

Total Students

Junior	1.13 1.58				
Sophomore	1.60 .79	.37 2.53[a]			
Freshman	.39 1.18	.91 .71	1.46 2.29[c]		
Total	.93 .64	.54 1.46	1.14 1.80	.63 .94	
Test 1 and 2	.87	.12	3.44[b]	.10	2.22[c]

Teachers

	Group I	Group II	Group III	Group IV	Total Students
Group II	.60				
Group III	.03	.47			
Group IV	1.40	.24	.82		
Total	1.08	.08	.54	.49	2.45[c]

[a]Second number indicates "t" values for second administration.
[b]Significant at 1 percent level of confidence.
[c]Significant at 5 percent level of confidence.

The significant difference between the mean locus scores of the three schools might emphasize the importance of the social structure of the various institutions upon student attitudes. There are no sororities or similar groups at School A, whereas these social groups are an important part of the life at the other two institutions. The differences obtained between individual class groups within and between schools may be characteristic of these specific groups and not of that particular classification in general. The size of the groups was toc small to permit any conclusiveness.

On the second administration of the TST, all groups, with the exception of the freshman group at School C, made a gain in mean locus score. Although the mean locus score of freshmen at School C was lower on the second administration, this difference was not significant. The difference between the means of School A and of School C was not significant. It would seem that elements in addition to the ones presented above were in existence and narrowed the range of differences between groups.

A curiosity about the test after the first administration may have encouraged some research or inquiry and an exchange of ideas about possible purposes behind the test. Tests of a similar nature were being used in experiments at two of the institutions. A knowledge of related tests or this exchange of ideas could have influenced the structuring or more appropriate answers on the second administration. The low but significant correlation coefficients of .32 and .45 obtained between the locus scores of the first administration and those of the second would indicate that there was a tendency to respond with similar or more consensual statements on the second test.

There was a significant difference between the mean locus scores of the teacher group and School B and of the teacher group and School C. The difference between the mean locus score of the teacher group and of School A was not significant. This similarity between scores of the teacher group and of School A might indicate that this particular school either encourages the development of self-attitudes more closely associated with teaching or attracts those students who already possess these particular self-attitudes. It must be remembered that the expressed purpose of School A is the training of teachers. Students enrolled in this particular school are committed to teaching. Upon entrance to the college they are requested to sign a pledge to teach upon completion of college work. It is possible that the lack of opportunity to participate in many social organizations outside the immediate group is a factor in the similarity of the locus scores of these two particular groups.

A further analysis of the teacher group according to educational background and type and size of school in which they teach might provide more insight into this similarity. Although there are no studies, in the knowledge of the writer, to support this observation, it seems that the demands of teaching would not aid in the development of those self-attitudes characteristic of a socially minded person.

Conclusions

The following conclusions are based upon the evidence obtained in this study:

1. There is a significant difference between the self-attitudes of women physical education major students within a school and between schools.

2. The self-attitudes of women physical education teachers differ significantly from those of students enrolled in either a liberal arts college or a teachers college connected with a university but are similar to the self-attitudes of those women physical education major students enrolled in a teacher education institution.

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(Submitted 1/20/58)

Maturation Age of 55 Boys in the Little League World Series, 1957

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Abstract

The X-ray films of the hands of 55 boys in the Little League World Series, 1957, were assessed for maturation (skeletal) age according to Todd's 1937 standards. There were four boys of chronological age 11:0-11:9, 42 of age 12:0-12:11, 9 of age 13:0-13:11. It was found that 16 boys (29%) were retarded, or maturation age *less* than chronological age; 39 boys (71%) were advanced, or maturation age *more* than chronological age. With correction of maturation age within ± one year of chronological age, the significant figures are five retarded, 25 advanced, for a total of 30. Of these 17 percent are retarded, 83 percent advanced. It is concluded that Little League ball players of championship caliber are, in general, biologically advanced. Such an advancement is deemed a positive factor in young boys indulging in competitive sports.

IN AN EARLIER STUDY Hale (1) has reported on levels of physiological (sexual) maturation in the 1955 Little League finalists. He found that most of the young teenagers were pubescent or postpubescent. The present report is an independent evaluation of maturational progress in still another physiological variable, the skeletal or bone age of the boys. Dr. Hale provided 55 X-ray films of the left wrist and hand of all boys in the 1957 finals, giving the name and birthday of each. Each X-ray film was assessed "blindly," i.e., all identifying marks on the film were blanked out.

The chronological ages represented in the series are as follows:

11:0 yrs.—11:11 yrs.	4
12:0 " —12:11 "	42
13:0 " —13:11 "	9

Each X-ray film was assessed using the Todd *Atlas* (2). All cases involving a considerable discrepancy between chronological age and skeletal age were double-checked, after a time interval long enough to eliminate a memory factor. On a spot-check basis, a colleague, Mr. William M. Bass, III, went over the discrepant group.

The results are shown in Table 1.

Analysis

Of the 55 boys, 16 (29%) were retarded, i.e, their skeletal age was *less* than their chronological age. Of the 55 boys, 39 (71%) were advanced, i.e., their skeletal age was *more* than their chronological age. These figures must be modified a bit, however. In my experience, for chronological age and skeletal age to differ about ±1:0 is within a normal, acceptable range of

TABLE 1.—SKELETAL AGE ASSESSMENT OF 55 LITTLE LEAGUE FINALISTS, 1957

Maturation Status		Chronological Age-Classes	
	11:0—11:11 yrs.	12:0—12:11 yrs.	13:0—13:11 yrs.
Retarded			
0:0—0:11	1	8	2
1:0—1:6	1	–	1
1:7—1:11	–	1	–
2:0—2:6	–	1	1
Totals	2	10	4
Advanced			
0:0—0:11	–	12	2
1:0—1:6	1	5	1
1:7—1:11	1	5	–
2:0—2:6	–	6	1
2:7—2:11	–	2	1
3:0—3:6	–	2	–
Totals	2	32	5

variation. Hence, all cases retarded or advanced 0:0—0:11 must be regarded as nonsignificant, i.e., normal. The number left as retarded is 5, as advanced is 25. This means that 30 boys are in the ranks of significance, when chronological and skeletal ages are being compared. Of these 30, 17 percent are retarded, 83 percent advanced.

A further breakdown is shown below:

Age	Average Advancement			Average Retardation		
11:0—11:11	1:4 yrs.	(1:1—1:7)	(2)	1:5 yrs.	(1:5)	(1)
12:0—12:11	2:0 "	(1:0—3:1)	(20)	2:1 "	(1:8—2:6)	(2)
13:0—13:11	2:1 "	(1:6—2:9)	(3)	1:9 "	(1:6—2:0)	(2)

(The first parenthesis=range, the second=frequency)

Discussion

In general, the successful Little League ball player is old for his age, i.e., he is biologically advanced. This boy succeeds, it may be argued, because he is more mature, biologically more stable, and structurally and functionally more advanced. This is fairly easy to figure out and seems reasonable and logical.

What of the boy who is seemingly equally successful as a Little League ball player, yet does not—we may argue—possess the reputed advantages of heightened maturity? Obviously, we must search for other variables that make for success as a ball player, possibly quite beyond the realm of biology. In this report I can but conjecture that these variables must be psycho-personal, in the realm of motivation, drive, desire, "guts," or any equivalent yardstick.

Advanced biological maturation is a favorable factor in Little League Baseball. It should be *one* of the screening mechanisms for eligibility and for evaluation of potential. There is one other observation to be made. If chronological age is *not* the main criterion of acceptability in Little League baseball then much of the onus of "exploration" of the teen-ager is removed. If biological age—the *real* age of functional maturity be the criterion, then each lad is protected, as it were, from the rigors of an exercise that might tax a real or relative immaturity.[1]

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[1] I still argue in favor of conservatism in the sports activities of the very young teen-ager. That is little more than common sense. But I register my opinion that recognition of biological age-screening is a very wise and useful protective mechanism.

(Submitted 7/22/58)

Effects of Fatigue and Warm-Up on Speed of Arm Movements[1]

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Abstract

Other studies have shown that a three component exponential fatigue curve can be used to compute speed as a function of elapsed time in running. The present investigation shows that this type of curve describes accurately the initial build-up in rate of arm-shoulder movements and subsequent drop-off from fatigue in a four-minute test and retest of twenty college men. Warm-up preceding one of the tests is found to have no influence. One test period causes a practice effect of 2.7 percent, chiefly in the first third of the curve. Test-retest reliability is low ($r = .51$) for the first five seconds of performance. For each third of the total test it is fairly high, ranging from .82 to .87.

SOME YEARS AGO there was a flurry of interest in the maximum rate of repeated arm-shoulder movements, particularly as it might be influenced by training with heavy resistive exercises. The drop-off in speed with the continuation of movements of this type has received little investigation. Apparently there has been no study of the possible effects of warm-up on these arm-shoulder movements, although the past few years have seen considerable research on warm-up in relation to several other types of performances.

Review of Literature

Speed and Fatigue in Arm Movements. Wilkin (11) studied the effect of weight training on the maximum speed of turning an unloaded two-arm crank of 7¼-in. radius placed at shoulder height. The initial mean speed was 209 revs/min. (timed for 15 sec.). It had dropped off to 149 revs/min. at the end of the 75-sec. test. The fatigue curve seemed to be exponential in form, with a half-time of 20 sec. Zorbas and Karpovich (12), who were also interested in the effect of weight training, used a crank of 8⅜-in. radius turned with one arm. The initial speed was 263 revs/min. Since the length of observation was only 5½ sec., the trend of the fatigue curve is unknown.

Recently there have been several studies of the fatigue curve for arm muscle strength. Grose (1) observed that when the forearm muscles make rhythmically repeated contractions at the rate of 30/min., there is an exponential drop-off in strength with a half-time of 30 sec. Royce (7) found that the two

[1] From the Research Laboratory of the Department of Physical Education, University of California, Berkeley. The writer is indebted to Dr. Franklin Henry for advice and for help with the mathematical analysis.

main components of the isometric fatigue curve are also exponential, with half-times of 38 and 84 sec.

Effects of Warm-Up on Performance. A recent study by Pacheco (5) has presented a review of the literature prior to 1957 on the effect of warm-up on physical performance. Under carefully controlled conditions both of her experiments showed that preliminary exercise used as a warm-up improves jumping performance. Subsequently, Skubic and Hodkins (8) did not secure significant improvement from very light warm-up exercise. Michael *et al.* (4), Swegan *et al.* (9), and Thompson (10) have reported that warm-up activities improve physical performance. In a more recent study, Pacheco has found that the jumping performance of junior high school girls is considerably improved as the result of preliminary exercise (6).

Problems Investigated

In order to investigate more fully the nature of the fatigue curve for a coordinated two-arm movement, it seemed desirable to extend considerably the length of the work period. The writer was also interested in examining the effect of warm-up exercises on this type of movement and in determining

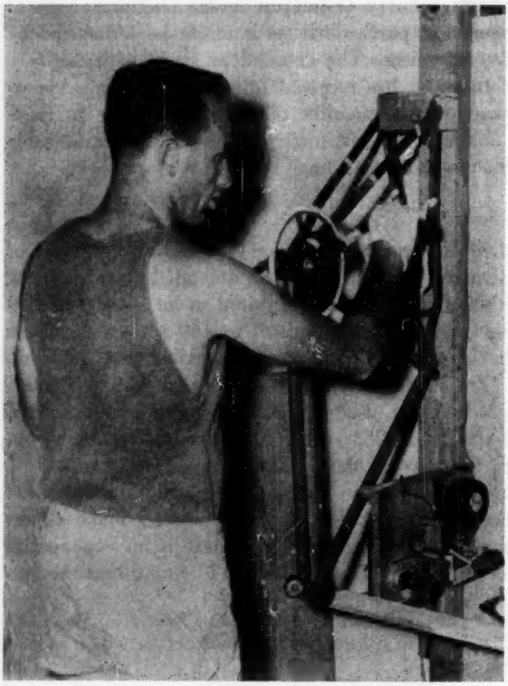

FIGURE I. Apparatus for measuring maximal rate of arm-shoulder movements.

whether the practice effect reported by Wilkin (11) influences the later parts of the fatigue curve as well as the initial speed.

Methodology

Apparatus. The apparatus consisted of a bicycle crank firmly attached to the wall, turned simultaneously with both hands (see Figure I). The height was adjustable to shoulder level. There was no resistance to rotation except the very small amount from the ball bearings of the crank. To prevent blisters, the subject wore cotton gloves. An electric counter was read at 10-sec. intervals, except for the first 20, when it was read every 5 sec. This same apparatus was used in the Wilkin experiment already cited.

Subjects. The subjects were 20 male university students between the ages of 19 and 34 years. On the day of the test, no muscular exercise was permitted except for a minimum of necessary walking.

Experimental Design. Each subject was tested twice, serving as his own control. A week elapsed between testing periods to avoid any effect from muscle soreness. The total group was divided randomly into two subgroups of 10 each. One group had four minutes of preliminary exercise on the experimental day, while the other group had two minutes. In order to balance out any practice or training effect in studying the influence of the warm-up, half of the subjects in each group did the pre-exercise on the first day and the control on the second day. The other half of each group were tested in reverse order.

Test Procedure. The preliminary exercise consisted of stationary running while simultaneously rotating both arms in a complete circle, alternating first forward and then backward. The exercise was done to the cadence of approximately two foot movements and one arm rotation per second. A two-minute rest was given after the warm-up exercise. In order to offset possible psychological effects on the experimental day of warm-up, the subject's attention was misdirected by informing him that the purpose of the test was to study the effects of various types and amounts of exercise on pulse rate. The pulse count was recorded before and after both preliminary and cranking exercises.

A ten-second practice run was given to each subject approximately five minutes prior to the first test. A determined effort was made to motivate each subject to turn the crank as fast as possible throughout the four-minute test period. The investigator is convinced from observing the test runs and noting the extreme fatigue of the subjects at the completion of the test that all subjects put forth a maximum effort.

Experimental Results

FATIGUE CURVES

Curve Fitting. The trend of the data for mean performance (plotted in Figure II) suggests that the curve levels off at about 139 or 138 revs/min.

The value 138 was taken as a trial estimate of the asymptote C and subtracted from each of the mean points at the various measured times ranging from 5 to 240 sec. To save on the arithmetic, successive groups of three 10-sec. intervals were averaged after the first 110 sec.

The subtracted values, representing amounts *above* the asymptote C, were then plotted as small circles on a semi-log graph (Figure III). A straight line was drawn through the trend of the points on the right-hand half of the graph, from 100 sec. onward. This straight line, called the a_3—k_3 component, intercepted the zero time axis at 32.6 revs/min., which was the value of the parameter a_3. The half-time for this straight line (i.e., the time required for it to drop to 16.3) was observed to be 87.1 sec.; this permitted calculating the parameter k_3 as $\log_e 2$ divided by the half-time, namely .693/87.1 = .00796.

The next step was to subtract, from each circled point, the ordinate value for that particular time read on the a_3—k_3 line. These subtracted values were plotted on the graph, using the symbol +, to establish the a_2—k_2 component. However, since the main curve dipped downward for the first few seconds, the values at 5 sec. and 10 sec. were plotted later, because they needed to have added to them the values of a_1—k_1 at those times. A straight line was drawn through the remaining seven points. Its intercept at zero time was 83.0

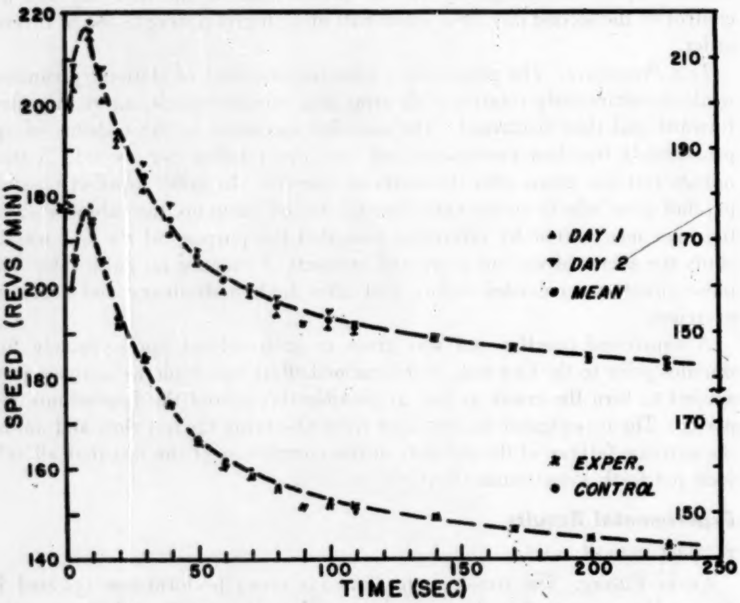

FIGURE II. Fatigue curves and observed rates of movement.

revs/min., which was the value of the parameter a_2. Since this component had such a steep slope, it was more accurate to determine k_2 by means of the tenth-time than the half-time. It required 46.3 sec. for the line to drop from 83.0 to 8.30. The parameter k_2 was computed as $\log_e 10$ divided by the tenth time, namely 2.303/46.3 or .0497. The halftime was 13.9 sec.

The sum of a_3 and a_2, 115.6, was subtracted from zero (since the speed was zero at time zero), yielding the value −115.6 for the parameter a_1. Next, the a_2—k_2 and a_3—k_3 values from the lines were summed and subtracted from the observed speed at 5 sec. (plotted as a circle); this was the value of the a_1—k_1 component at 5 sec. The values at 10 sec. and 15 sec. were determined by a similar procedure. These a_1—k_1 values (including the value at time zero) were plotted using the symbol x. A straight line through these points furnished the tenth time of this component, which was 7.95 sec., permitting the calculation of k_1 as .290, and the half time as 2.39.

The complete formula:

$$y = a_2e^{-k_2t} + a_3e^{-k_3t} - a_1e^{-k_1t} + C$$

permits calculation of the smooth curve drawn in Figure III (before adding the asymptote C), as well as the smooth curves of Figure II (after adding C),

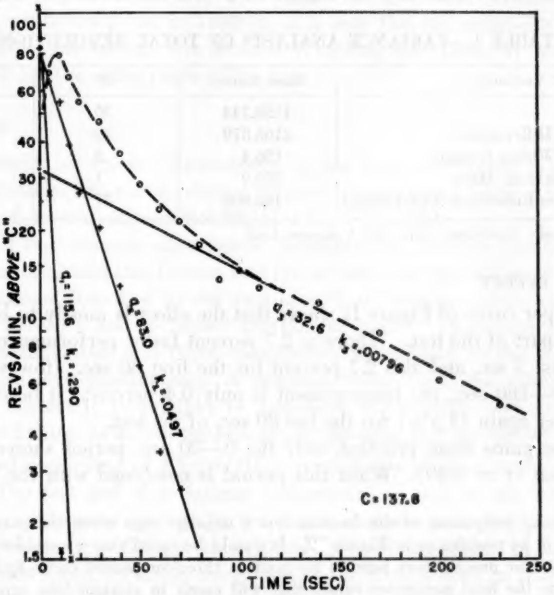

FIGURE III. Exponential analysis of curve components.

using the parameter values given in Figure III.[2] The meaning of the three terms of the formula will be discussed later.

Accuracy of Fit. A slight correction of C, from the trial value 138.0 to 137.8, eliminates the small constant error. The standard deviation of the differences between the values computed from Formula 1 and the mean observed values plotted as a dot at each time period in Figure III is 1.91, which is an average discrepancy of 1.1 percent. The largest single discrepancy, at the 90 sec. point, represents only 2.1 percent error. The computed curve is thus seen to fit the observed data very accurately.

WARM-UP

Contrary to expectations, there is no evidence that the warm-up exercise has improved performance. It can be seen in the lower curve of Figure II that the speed is not consistently higher under the experimental conditions in any region of the curve, and the differences are all very small.

When the total number of revolutions turned in the four-minute tests are compared for experimental and control conditions, it is found that on the average the subjects did slightly *worse* (1.1%) than the control when using the two-minute warm-up, and slightly better (0.4%) when using the four-minute warm-up. A variance analysis of the results (Table 1) reveals that the warm-up effect is definitely not significant, since the F-ratio is only 0.76.

TABLE 1.—VARIANCE ANALYSIS OF TOTAL REVOLUTIONS

Source of Variance	Mean Square	df	F
Total S. S.	1158.744	39	—
Individual Differences	2165.579	19	13.00[a]
Warm-Up Within Groups	126.4	2	0.76
Practice Between Days	959.9	1	5.76[a]
Error (Intra-Individual Differences)	166.606	17	—

[a] Statistically significant above the 5 percent level.

PRACTICE EFFECT

The upper curve of Figure II shows that the effect is mostly to be found in the early part of the test. There is 2.7 percent faster performance on Day 2 for the first 5 sec. and also 2.7 percent for the first 80 sec. However, for the period 80—160 sec., the improvement is only 0.4 percent. It becomes somewhat larger again (1.5%) for the last 80 sec. of the test.

Of these gains from practice, only the 0—80 sec. period shows statistical significance ($t = 3.40$). When this period is combined with the later ones,

[2]The a_1—k_1 component of the formula has a negative sign when the parameter a_1 is considered to be positive as in Figure III. It should be noted that a considerable amount of trial-and-error process may have to be used in three-component curve fitting in order to determine the final parameter values that will result in straight line exponentials on the semi-log graph.

TABLE 2.—REVOLUTIONS TURNED AT DIFFERENT PARTS OF THE FATIGUE CURVE

Statistic		Test Time (sec.) 0-5	0-80	81-160	161-240	0-160	0-240
Day 1	M	16.95	232.3	199.5	191.0	431.8	622.8
	σ	1.431	13.11	12.13	11.83	23.62	33.76
Day 2	M	17.40	238.5	200.3	193.8	438.8	632.6
	σ	1.744	13.59	12.68	10.46	23.75	32.74
Practice Effect	M	0.45	6.2	0.8	2.8	7.0	9.8
	t	1.75	3.40*	0.48	2.03	2.23*	2.43*
Test-Retest	r	.509	.822	.832	.870	.833	.861

* Statistically significant at the 5 percent level.

the practice effect for the cumulated turns at both 160 and 240 sec. is significant (see Table 2). The results for total turns at 240 sec. are confirmed by the variance analysis (Table 1); the F-ratio is 5.76 compared with 4.45 required for significance at the 5 percent level.

TEST-RETEST RELIABILITY

Since the warm-up is without significant influence, the scores on Day 1 can be correlated with those on Day 2 to secure the test-retest reliability coefficient. The results are given in Table 2. It is seen that the reliability is rather low ($r = .509$) for the first five seconds of turning the crank. It ranges from .822 to .870 for the other parts of the test.

Discussion

Interpretation of Curve Components. It has been discovered that in running performance, the curve relating speed to distance (or elapsed time) is a composite of several exponential terms (3). For events requiring no more than four or five minutes when run at the maximum possible speed throughout, the runner accelerates for the first six seconds and thereafter slows down (2) in a manner described by the sum of a "fast" fatigue component a_2e^{-k2t} (half-time 27 sec.) and a "slow" component a_3e^{-k3t} (half-time 200 sec.). It has been suggested that these components are related to the alactic and lactic oxygen debt mechanisms. A negative component, designated a_1e^{-k1t} (half-time 2.8 sec.), is thought to represent acceleration and energy loss factors that behave as a counter resistance opposing fast movement (3).

The speed-time curve of Figure III is remarkably similar to the curve for running. The fast and slow fatigue components as well as the negative or energy loss component emerge in the curve analysis, and the half-times of these components are of the same relative order of magnitude in both cases. The maximum speed occurs in the region of the sixth second in both. It may be noted that the half-times of the two fatigue components are similar to the

main components of the isometric fatigue curve for arm muscles, namely 38 and 84 sec. (7).

Rate of Turning. Wilkin (11) reported rates of 209, 180, 168, 156 and 149 revs/min. in five successive quarter-minute periods.[3] In the present experiment, the corresponding speeds are 209, 187, 172, 163 and 158 revs/min. in the first five quarter-minute periods. The agreement is exact in the first quarter-minute, but the rate of fatigue is slightly less than in the Wilkin experiment. The total revolutions turned in 75 sec. in the present study is 222 ($\sigma = 12.54$), compared with the Wilkin value of 216 ($\sigma = 17.75$). The t-ratio of the difference, 1.53, is not statistically significant.

Reliability. Wilkin reported a test-retest reliability coefficient of .751 for his control group. The corresponding value in the present experiment is .822, which agrees with the Wilkin result within the limits of sampling error ($t_z = 0.66$, not significant).

Warm-Up. The effectiveness of warm-up exercise in a wide range of activities has not received extensive controlled investigation. While its usefulness has been well established in vertical jumping (6), it was not beneficial in the present experiment. Warm-up exercises have so far been found ineffective in sprint running and certain other kinds of performances as pointed out in the review by Pacheco (5). Thompson (10) failed to secure positive results in the case of swimming performance unless the pre-exercise was combined with hot showers; Skubic and Hodgkins (8) found the improvement from light pre-exercise was not significant in a softball throw for distance, a 13-sec. bicycle sprint for speed, or a basketball throw for accuracy. There seems to be a need for considerably more controlled research in the area of warm-up, in order to learn why it is effective in some situations and ineffective in others.

Summary and Conclusions

Fatigue curves for the maximal rate of arm-shoulder movements during four minutes of crank turning were secured on 20 college men. There were two tests per subject, one of them preceded by either a two- or four-minute warm-up exercise. A balanced order of testing was used. The curves were fitted by a three component exponential equation of the same form that had been employed by others to describe the initial rise and subsequent drop-off in speed during all-out running. The accuracy of fit was very high. Data reported by others for a 1¼-minute crank turning test were in close agreement with the present experiment, both as to speed and test-retest reliability. An

[3] The Wilkin data were fitted with a single component exponential equation. This does not really constitute disagreement with the present study. His use of relatively long time periods (15 sec. rather than 5 sec.) would mask the initial build-up in speed, and the total length of his test (75 sec.) would be too short to determine adequately the asymptote value or to reveal the presence of the slow fatigue component.

analysis of variance was used to determine which variables had statistically significant effects.

The results lead to the following conclusions:

1. Warm-up exercises are without effect under the conditions of this experiment.
2. Speed of movement on the second of two crank-turning tests is faster as a result of a practice effect. The improvement is chiefly in the initial speed and the first part of the fatigue curve.
3. The test-retest reliability tends to be low (.51) for the first five seconds of performance. It is fairly high for the first 80 seconds of turning (.82), and tends to increase slightly in the remaining parts of the fatigue curve.
4. The crank-turning test appears to give reproduceable results.
5. There is an initial build-up in speed, reaching a peak somewhere between five and ten seconds, before fatigue causes slowing of movements.
6. The three component exponential equation for speed-time relationships describes the data accurately and appears to have considerable generality of application.

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(Submitted 9/4/58)

Influence of Massage on Jumping Performance[1]

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Abstract

Using a psychological control (placebo) and a balanced experimental design to secure unequivocal results, it was found that pre-exercise massage yielded 2.6 percent improvement in the vertical jumping performance of 36 college men. The amount of improvement was twice as large in the fifth and sixth trials as in the preceding jumps of the six-trial test series. The average jump (48.8 cm.) and the test-retest reliability ($r = .94$) agreed closely with previous studies using the Henry jumping apparatus. During the six jumps of the first day (without massage), the practice effect caused 3.6 percent improvement, but there was no significant practice effect during the second or third day of testing or between three successive days spaced one week apart.

MANY COACHES, TRAINERS, AND ATHLETES believe that performance is improved if the proper muscles have been massaged just before engaging in a physical activity. Certain physiological explanations have been advanced in support of this practice. Controlled experiments on the problem are few and are controversial in their implications.

Review of Literature

Effect on Nervous System. Graham (5) believes that massage usually exerts a peculiarly delightful sedative effect on the nervous system as well as a profoundly tonic one. Bucholz (3) states that massage influences primarily the endings of the sensory nerves in the skin and other peripheral organs. This influence is variable according to the number of nerve endings stimulated and to the character of massage applied. He also contends that the superficial layers of the epidermis as well as the greasy deposit are removed. By this method the openings of the sebaceous glands are freed and their secretions favored. The function of the sweat glands is stimulated and the respiratory and absorptive function of the skin improved. The position of Pemberton *et al.* (13) is that with massage the nervous system contributes to a reflex influence (probably through the sympathetic division) on the blood vessels of the parts concerned. Because of this, vessels within the muscular system or elsewhere are emptied during massage, not only by being squeezed but also through this reflex action. They also contend that dilation of the small vessels following very light stroking affords illustration of the functioning of the nervous mechanism.

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[1]From the Research Laboratory of the Department of Physical Education, University of California, Berkeley. The writer is indebted to Dr. Franklin Henry for advice and encouragement.

Effects on Circulation and Lymph. Mitchell (10) investigated the effects of general massage on blood. He tested 35 subjects, some healthy but most of them suffering from anemia. In nearly all cases after massage, there was found a large increase in number of red corpuscles and to a lesser degree an increase in their hemoglobin value. Schneider and Havens (15) found that abdominal massage on six subjects increased the hemoglobin and red cell count. Kleen (9) contents that massage gives both the rested and fatigued muscles more strength and endurance and causes stronger reflexes. Three to five minutes of massage often have a greater effect on the fatigued muscles than 20 minutes of rest and produce three to seven times greater manifestations of strength.

Wolfson (16), in a study on the effect of physical therapeutic procedures on function and structure, finds that massage causes a great initial increase in blood flow with a fairly rapid decrease to a rate less than normal even before the end of treatment. This seemed to be purely a mechanical action, the initial rise being due to a forced evacuation of the blood vessels which is so complete that the blood flow seems to stop by the end of the manipulation. Immediately following the cessation of the procedure the blood flow slowly returns to normal because it must not only resume flow but also fill the evacuated and compressed blood vessels. Wolfson therefore concludes that the actual volume of blood which passes through the limb during the period of stimulation and recovery is not greater than normal, but that there is a more complete emptying for a short period of time and therefore a greater supply of fresh blood brought to the part. Pemberton *et al.* (13) state that the important direct influence of massage is on the local circulation of the parts treated and consequently, to some extent, on the circulating fluids of the body as a whole. In contrasting active muscular exercise and massage, these workers argue that massage, no matter how vigorously administered, does not produce lactic acid or acidosis. Changes in the blood supply of muscle brought about by massage cause a more rapid removal of the lactic acid already contained in the muscle. They feel that these conclusions are of great importance in explaining the value of massage to the exercised muscles of athletes; this beneficial influence is well known to athletic trainers and is widely used by them in connection with treating traumatized muscles. Beard (2) holds that massage produces mechanical effects on the circulation by assisting the venous and lymphatic return.

Effect on Metabolism. Cajori *et al.* (4), utilizing 20 subjects in a controlled experiment designed to seek information as to the physiological effects of massage, find that the excretion of urinary acid is not altered after massage and there is no disturbance of the acid-base equilibrium of the blood. An increased rate of excretion of nitrogen, inorganic phosphorous, and sodium chloride is observed more frequently following massage than during the control period. The rate of excretion of creatine is not influenced. They think that the benefits of massage seem to depend on broad physiologic effects

rather than on its influence on any specific product of metabolism. They conclude from their experiments that massage has no immediate or great influence on general metabolism per se. The cumulative effect which massage exerts on the various metabolic processes probably lies in its mechanical influences on the circulation of the parts concerned.

Effects of Massage on Performance. Asmussen and Boje (1), using two subjects exercising on the bicycle ergometer, report that massage causes no significant improvement in performance. Karpovich and Hale (8), testing seven subjects in a 440-yard run, conclude that pre-exercise massage has no significant effect. Recognizing the importance of psychological control, they used "digital stroking" as a placebo. Grose (6) finds that in 12 subjects tested with the hand dynamometer ergograph, pre-exercise massage of the forearm muscles has no significant eflect on total work output, initial strength, or final strength.

Comment. Negative results on two subjects or seven subjects seem inadequate to prove conclusively the lack of effectiveness of massage on performance. Also, it is possible to interpret the factual data of Asmussen and Boje, as well as those of Karpovich and Hale, as evidence for a beneficial effect, as will be explained in the discussion. The Grose experiment utilizes localized treatment and performance in the forearm muscle, rather than more general treatment and performance in large groups of muscles working in a total body situation. In the latter case, both lymphatics and blood circulation might be more definitely influenced by massage.

Psychological control, which is very important in establishing unequivocal results in experimentation of this kind, has only been used in the Karpovich and Hale study. However, as can be seen from the work of Pemberton *et al.*, the use of "digital stroking" as a control is undesirable, since it might have a physiological as well as a psychological effect.

Problem Investigated

It is evident from the review of the literature that it is controversial as to whether or not pre-exercise massage has a beneficial effect on athletic performance. Before investing time and effort in further study of the possible mechanisms involved in questionable improvement of performance, it seems important to establish, by the use of adequate numbers of subjects tested with an effective experimental design and psychological control, that the effect either does or does not exist.

The specific physical performance chosen for investigation is vertical jumping. Reasons leading to this choice are that vertical jumping is an important element in a number of athletic activities. It can be standardized to a high degree. It has been reported to be relatively uninfluenced by practice effects in college men and seems to yield highly consistent data (11). It is possible to measure this performance in the laboratory, using a convenient recording instrument.

Methodology

Apparatus. Performance was measured by Henry's vertical jump apparatus (7). In this device a cord passes from the subject to a pulley about 15 feet above his head. It then comes down to another set of pulleys which turns it horizontally. A spring maintains constant tension on the cord, so that when the subject jumps the cord moves an indicator which can be read conveniently to give a measure of the height jumped. The apparatus has recently been described in detail by Pacheco (11).

Experimental Design. Thirty-six male university students between the ages of 17 and 39 took part in the experiment. In this study (as in Pacheco's), the subject was told to keep his arms naturally at his side while jumping, to reduce variability caused by special techniques which might also cause practice effects. This method is in contrast to the classical Sargent jump (14) where the arms are brought up above the head before the leap and then snapped down during the ascent in order to give additional height.

The subject jumped in his stockings wearing ordinary clothing. It was extremely important to ensure that the subject was not "warmed up" before taking either experimental or control tests. Retests were always given at the same time of day as the initial test. Six trials, each separated by 1½ minutes' rest, were given on each test day. One of three different pre-jump conditions preceded each day's testing of a particular subject. These conditions were as follows: I. ordinary control, II. psychological control (pseudo-high frequency cellular massage), and III. ten minutes of vigorous manual massage.

All subjects were tested under Condition I the first day. This was intended to be a practice session for the subjects to get used to the apparatus and technique. On the second day, a week later, a random half of the subjects (Subgroup A) was tested under Condition II. On the third day (after another week) this subgroup was tested under Condition III. The other half of the subjects (Subgroup B) was tested under Condition III, on the second day. This was followed a week later by Condition II, thus giving a balanced order for II and III.

FIGURE I. The electronic device used for the psychological control.

Condition II was a psychological control, using the method of misdirected attention which has been used effectively at this laboratory in other experiments (12). An electronic device (Figure I) in a professional-looking case emitted a high frequency sound. A round applicator disk protruding from the case (thermally and acoustically insulated) was applied directly to the anterior and

posterior thigh, buttock, and calf muscle for 10 minutes (five minutes on each limb). Suitable comments concerning the possible virtues of the new "experimental cellular massage" accompanied treatment. It was explained that the high frequency vibration could not be felt, as it was higher than the vibratory threshold. The writer is certain, through general comments from the subjects during this phase of the test, that most of them accepted the explanation.

Condition III consisted of a combination of deep stroking and kneading massage on the anterior and posterior thigh, buttock, and calf muscles, for 10 minutes (five minutes on each limb). The writer practiced the technique under the direction of the university athletic trainer for several weeks.

Experimental Results

Effects of Massage. The mean performance of the 3[illegible] subjects under the massage conditions is 49.44 cm., as shown in Table 1. This is significantly higher than the performance of the same subjects utilizing the placebo control (48.17 cm, t = 3.19). The increase from massage is therefore 1.27 cm., which is 2.6 percent improvement. A variance analysis (Table 2) confirms this finding. The F-ratio is 23.61 on Day 2 and 7.77 on Day 3, compared with 6.78 required for significance at the 1 percent level. The effect of massage seems to be greatest on Trials 5 and 6, where it is more than twice as large as in the earlier trials of the experimental treatment day (see Table 1).

TABLE 1.—EFFECT OF MASSAGE ON JUMPING PERFORMANCE

Trial	Placebo	Massage	Gain	t
1	48.18	49.12	0.94	1.66
2	47.90	48.66	0.76	1.13
3	48.32	49.24	0.92	1.23
4	48.26	49.18	0.92	1.44
5	48.05	50.08	2.03	2.90[a]
6	48.33	50.35	2.02	3.16[a]
Average	48.17	49.44	1.27	3.19[a]

[a] Significant at the 1 percent level. Table gives mean jump in cm. for 36 subjects.

TABLE 2.—VARIANCE ANALYSES OF PRACTICE EFFECT WITHIN DAYS
(Daily averages are given in the lower part of the table)

Source of Variance	d.f.	Day 1 MS	Day 1 F	Day 2 MS	Day 2 F	Day 3 MS	Day 3 F
Total	215	44.461	—	45.496	—	47.597	—
Subjects	35	235.923	33.77[a]	247.503	44.04[a]	257.287	40.31[a]
Trials	5	15.880	2.27[b]	1.692	0.30	13.632	2.14
Treatment	1	—	—	132.710	23.61[a]	49.600	7.77[a]
Error	174	6.986	—	5.620	—	6.629	—
Mean and S.D.		48.651	6.19	48.767	6.43	48.851	6.75
Corrected Average		48.651	—	48.136	—	48.220	—

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level, using 175 d.f. for error on Day 1.

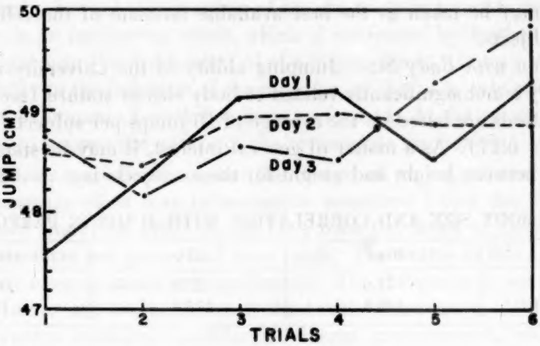

FIGURE II. The practice effect within the six jumps on each day.

Practice Effect within Days. The practice effect within the six jumps on each day is shown in Figure II and evaluated by the variance analyses shown in Table 2. The gain between any two consecutive trials is not statistically significant, but the improvement during the first two jumps on Day 1 does meet the 5 percent criterion (1.22 cm. based on the error term of the variance analysis, which can be used since the F-ratio for trials is significant). There is no significant increase in performance between trials within days on Day 2 and Day 3.

Practice Effect between Days. Table 2 also shows the data for the mean height jumped on Days 1, 2, and 3. The entries designated *corrected average* require explanation. As shown above, the mean experimental effect was 1.27 cm. Since half the subjects on Day 2 were treated, and half on Day 3 were treated, the *untreated* means for these two days may be assumed to be too high by half of the massage effect. However, the difference between Days 2 and 3, namely 0.084 cm., with a t-ratio of 0.04, represents the net practice effect as between these two days and would be the same for both corrected and uncorrected means. The estimated practice effect as between Days 1 and 2 would have to use the corrected mean for Day 2, and would indicate a *loss* in performance (−0.515 cm).

Another estimate of the influence of practice can be made by comparing the scores on Day 1 with those on the placebo control test which is Day 2 for half the subjects and Day 3 for the other half. Again there is a small and nonsignificant *loss* in performance (−2.717 cm.; t = 1.10), which confirms that there was no practice effect and no placebo effect.

Test-Retest Reliability. This may be estimated by computing the correlation of mean daily scores of each individual on Day 1 with the scores on the control test (r = .9277), and also the correlation between the scores for experimental *vs.* control conditions (r= .9535). The average of these, namely

r = .941, may be taken as the best available estimate of the reliability for these 36 subjects.

Correlation with Body Size. Jumping ability of the university men tested in this study is not significantly related to body size or stature (see Table 3). The correlations are based on the average of 18 jumps per subject (M = 48.8 cm.; S.D. = 6.17). As a matter of general interest, it may be stated that the correlation between height and weight for these subjects is r = .6230.

TABLE 3.—BODY SIZE AND CORRELATION WITH JUMPING PERFORMANCE

	Mean	S.D.	Correlation
Height (in.)	71.6	2.78	.0603
Weight (lbs.)	176.8	17.73	−.1956

Discussion

In the present study, the beneficial effect of massage on large-muscle performance is clearly established. This finding disagrees with the Karpovich and Hale *conclusions* but does agree with their actual data. The amounts of improvement from massage in the individual subjects tested by Karpovich and Hale were 0.9, -0.1, 0.6, 1.0, 0.7, 1.1, and 0.4 seconds in the 440-yard run, which yields a t-ratio of 4.24. Their statement that there was no significant effect was based on an incorrect statistical evaluation (6, p. 21).

The present study also disagrees with the *conclusions* of Asmussen and Boje but does agree with their factual results. They tested two subjects, each under two work loads on the bicycle ergometer. The performance of one of them was improved at both work loads, and the other improved at one work load and showed no change at the other task. Therefore, three of their four experiments gave results in favor of massage. It disagrees with the results of a different type of experiment done by Grose, who failed to find any effect of massage on local muscle strength or fatigue.

In comparing the average jumping performances observed by Henry (7) and Pacheco (11) and those found in the present study using the same apparatus, it may be noted that the mean without preliminary exercise or massage was 0.14 cm. higher in the Pacheco study than in Henry's (t = 0.11), 0.53 cm. higher in the present study than in Pacheco's (t = 0.34), and 0.67 cm. higher in the present study than in Henry's (t = 0.52). These differences definitely are not statistically significant. The reliability is very close to the coefficients reported by Henry and by Pacheco; in fact, it is almost exactly halfway between their findings. The absence of correlation between body size and jumping ability, as found in this study, agrees with the observations of Pacheco.

The finding of a small but statistically significant practice effect *within* the first day of jumping agrees with the observations of Henry. The absence of a significant practice effect *as between days* agrees with the Pacheco results.

The tendency for only the last few of the six trials in a test to be improved by massage is an interesting result, which if confirmed by further work may lead to insight into the mechanism of the improvement. It may signify that there is a delay in the influence of the massage, or that it is only effective after a considerable amount of work has been performed. At the present time it is not possible to suggest the nature of the responsible mechanism.

There are strong indications that the design of an experiment to demonstrate the massage effect may be somewhat sensitive. Using the test exercise of the present study, the effect would have been too small to establish statistically if only three test jumps had been made. The t-ratio in this case is 1.98, which is only close to statistical significance. The difference is not established until four jumps are averaged, when the t-ratio increases to 2.93. The fifth and sixth jumps exhibited considerably larger improvement, which was in each case found to be statistically significant when tested as a single jump (Table 1).

Summary and Conclusions

Thirty-six male university students were tested to determine whether or not there is a beneficial effect on athletic performance of pre-exercise massage. Each subject performed six trials of standardized vertical jumping per day, under each of three conditions preceding the jumps. Condition I was a practice session for the subjects to become acquainted with the apparatus and technique. Condition II was a psychological control, using the method of misdirected attention. Condition III was a combination of deep stroking and kneading massage. A random half of the subjects received Condition II and the other half Condition III on the second day, with the order reversed on the third day in order to balance out possible practice and fatigue effects.

Compared with the control condition, preliminary massage improved average performance by 2.6 percent (significant at the 1% level). The effect was small for the first four trials of the six trial test (1.8%) but increased to 4.2 percent improvement for trials five and six.

There was a noticeable and significant practice effect within the first six jumps of the first day. However, on Days 2 and 3 no evidence for an increase in performance between trials within days could be detected. The data failed to yield any indication that a statistically significant practice effect occurred as between days. The test-retest reliability of the average of the six jumps was quite high ($r = .944$). The mean height of the jump was 48.8 cm. These two findings agree closely with the values reported by others. There was no significant correlation between either height or weight and vertical jumping ability.

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Variables Affecting Kraus-Weber Failures among Junior High School Girls[1]

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Abstract

Kraus-Weber test results of more than 1400 junior high school girls of two schools with different physical education programs were compiled three times per year by intelligence quotient, age, and physical type categories to determine the interrelationship of these factors and their significance to failure of the test. The results reveal that Kraus-Weber test failure is positively correlated with intelligence; that intelligence, age, and physical type are interrelated with one another, and with Kraus-Weber failure; that a program of exercises based on physiological needs produces rapid gains in strength and flexibility, for after one semester of a program including conditioning exercises, these girls, most of whom had had no physical education before this experiment, matched the European children's rate of success in passing the Kraus-Weber test.

THE KRAUS-WEBER TEST, originated at the Posture Clinic, Columbia University, Presbyterian Hospital, New York City, as a clinical test for minimum muscular fitness necessary to maintain normal health, is a battery of six subtests: two for the abdominal muscles, two for the back muscles, one for the psoas muscles, and one for flexibility of the back and hamstring muscles. It is a pass or fail test, for failure in any one of the subtests constitutes failure of the Kraus-Weber test.

The Kraus-Hirschland study revealed that European children failed this test at a rate of 8.7 percent and American children at a rate of 57.9 percent (4). Recent studies made with the Kraus-Weber test, as reported in the *Research Quarterly*, have attempted to establish the status of American children. In independent studies the highest failure rate was 66.1 percent in an Iowa study (1); the lowest failure rate was 38.1 percent in an Oregon survey of elementary school children (3).

Purposes

This study sought to analyze the relationship of certain variables upon the high rate of failure of the Kraus-Weber Test for Minimum Muscular Fitness as applied to junior high school girls and to determine the value of conditioning exercises. Specifically, the purposes were as follows:

1. To investigate the extent to which intelligence quotient, age, and phys-

[1] Ac!nowledgment is extended to H. Harrison Clarke, University of Oregon, for his advice and encouragement in the preparation of this study.

ical type are associated with Kraus-Weber failure, and the interrelationship of these factors.

2. To determine the results of conditioning exercises on Kraus-Weber test failures.

3. To further establish the value of the Kraus-Weber test as a criterion of minimum muscular fitness for American children.

Procedure

For this experiment all testees were in classes taught by the author. All girls in the required physical education classes of the Cochran and Garfield Junior High Schools of Johnstown, Pennsylvania, grades 7 through 10, ages 11 to 17, were tested over a period of 12 months to determine their gains or losses in ability to pass the Kraus-Weber test. Testing of the Garfield girls was continued a second year, and the scores of Garfield girls only are recorded in the fifth and sixth tests. The first test had 1421 subjects, the second 1099, the third, 1096, the fourth 767, the fifth 386, the sixth 375. None of these girls had participated in a conditioning program for 15 months prior to the administration of the first Kraus-Weber test; most of them had never participated in scheduled physical education classes.

At Cochran the girls were tested in September and November 1955; May and September 1956.[2] The Garfield girls were tested in September and November 1956; in May, September, and November 1957; and in May 1958.

Between tests the girls participated twice each week in conditioning exercises accompanied by music for part of their class periods. Once learned, the exercises did not consume more than seven minutes of the maximum exercise time of 30 minutes, in classes averaging 42 girls. Cochran girls were given the conditioning exercises for only eight weeks at the beginning of the school year. Garfield girls, who had a play program prior to this experiment, were in greater need of conditioning as revealed by the first test and were given the series of exercises for 14 weeks—eight at the beginning of the term, five at intervals throughout the year, and one during the last month of school.

Other physical education activities for the subjects included relays, games of low organization, posture and body mechanics, marching, stunts and tumbling, hand apparatus, rope jumping, golf swing, indoor soccer, basketball, volleyball, parallel bars (optional), tap dancing, and social and square dancing with the boys' gymnasium classes.

For each testing period the results were tabulated by intelligence quotient, age, and physical type categories to determine the relationship of these factors with minimum fitness and the effects of conditioning exercises on failure rate. In this experiment, intelligence quotients, determined by Otis Intelligence Test scores, or by the Binet Test scores for some of the very low intelligence group, were secured from official school records. Physical type categories

[2] The author extends acknowledgment to Janet Mitchell, certified Kraus-Weber tester, for testing the Cochran girls in September 1956.

were determined with the use of the Bird T. Baldwin Measuring Scale, published in January 1952 by the School District of Philadelphia.

Analysis by Intelligence

To establish the relationship of intelligence to Kraus-Weber test failures, the original test scores of all participants from both schools were recorded at one-point intervals, and failure percentages were computed in the following intelligence quotient divisions, as proposed by Terman: above 120, very superior; 110 to 119, superior; 90 to 109, average; 80 to 89, dull; below 80, moron. As the group with low intelligence quotients was relatively small, all those with intelligence quotients below 90 were grouped together for tests four, five, and six. Those with intelligence quotients above 110 were grouped together for tests five and six for the same reason. Results of this phase of the study appear in Table 1. The column labeled *Cochran 9-10* presents the percentages for the girls with earlier conditioning; under the *New* heading are the percentages for the girls who had not had any previous conditioning.

A decrease in Kraus-Weber failures occurred at all levels of intelligence with the very superior girls consistently having the lowest failure rate. Where the number of subjects exceeded 1000, results show that as test failures increased, intelligence quotients decreased.

Mathematical Analysis of Kraus-Weber Failures by Intelligence Quotients[3]

For mathematical computation the Kraus-Weber test scores of all subjects were put into classes with intervals of five I.Q. points each. The data for each of the five testing periods were divided into pass or fail groups. The mean I.Q. for each pass and fail group was found for each testing period; the percent of failure versus I.Q. points was plotted and a trend line found. The students who passed the test were found to have the higher mean I.Q.'s in each instance. When the difference of the means for the first testing period (1421 subjects) was tested for statistical significance, using the standard error of the difference, the critical ratio was 4.5.[4] At the 1 percent confidence level the ratio should exceed 2.58 to be significant from a statistical point of view; therefore the ratio of 4.5 is statistically significant. Stated another way, there is one chance in 100,000 that the difference is *not* significant (6).

[3]The author wishes to express appreciation to I. L. Stright, director of graduate studies, State Teachers College, Indiana, Pennsylvania, for his professional advice and to Henry F. Walter for the mathematical computations.

[4] The trend lines were found by the method of least squares using the normal equations:

$$\Sigma Y = m\ \Sigma Y + bn$$
$$\Sigma XY = m\ \ \Sigma X^2 + b\Sigma X$$

The coefficient of correlation is Pearson's r, found from the scatter and standard deviation of the ordinant values. $r = \sqrt{1 - S\gamma^2/\sigma\gamma^2}$
These may be found in Richardson (6, pp. 210, 238).

TABLE 1.—PERCENTAGES OF KRAUS-WEBER FAILURES BY INTELLIGENCE QUOTIENTS FOR THE VARIOUS TESTING PERIODS

Intelligence Quotient	Cochran 9-10[a] 1st Test	New[b] 1st Test	First Year 1st Test	First Year 2nd Test	First Year 3rd Test	Second Year 4th Test	Second Year 5th Test[c]	Second Year 6th Test[c]
Above 120	16.66	50.00	43.18	9.09	1.29	13.53		
110 to 119	21.12	51.91	45.81	9.96	5.37	18.62	2.27	1.98
90 to 109	35.20	54.46	51.60	16.14	9.95	18.18	6.27	3.63
80 to 89	53.84	64.83	63.36	21.91	17.56	34.42	3.22	4.16
Below 80		66.66	66.66	41.66	17.39			
Average	30.39	55.52	50.80	15.01	8.27	19.16	4.63	2.93
Number of Subjects	227	1,194	1,421	1,099	1,096	767	386	375

[a] Those who had 15 months' relief from earlier conditioning.
[b] Those who had not been taught by the author, and subjects who had no physical education prior to the first test.
[c] Regrouping of I.Q. groups: All those above 110 together and all those below 90 together.

TABLE 3.—PERCENTAGES OF KRAUS-WEBER FAILURES BY AGE FOR THE VARIOUS TESTING PERIODS, SHOWING PERCENTAGE DIFFERENCE BETWEEN FIRST AND FOURTH TESTS

Age	First Year Cochran 9-10[a] 1st Test	First Year New[b] 1st Test	First Year 1st Test	First Year 2nd Test	First Year 3rd Test	Second Year 4th Test	Second Year 5th Test	Second Year 6th Test	Difference between first and 4th Tests[c]
11 and 12 Years		49.89	49.89	16.66	8.04	16.53	2.54	1.68	33.36
13 Years	23.52	50.97	48.24	14.81	8.36	18.81	2.11	1.44	29.43
14 Years	31.25	59.33	50.16	20.50	9.31	31.25	7.92	6.31	18.91
15 Years and Older	33.00	66.66	55.88	30.20	13.69	42.10	7.14	4.16	13.78
Averages	30.39	55.52	50.80	15.01	8.27	19.16	4.63	2.93	31.64
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[a] Those who had 15 months' relief from earlier conditioning.
[b] Those who had not been taught by the author, and subjects who had no physical education prior to the first test.
[c] First and fourth tests given in September one year apart.

TABLE 2.—SLOPE, CORRELATION, AND MID-POINT OF TREND LINES FOR FIGURE I

Test	Symbol	% Change Per 5 I.Q. Points	r	% Failure at Midpoint (I.Q. 100)
1st	△	−3.05	.96	54
2nd	○	−2.65	.95	18
3rd	⊙	−1.60	.97	9
4th	□	−2.60	.88	23
5th	(not shown)	+ .20	.37	2

In test one, in which a decrease of 3.05 percent per five I.Q. points was found, the percent of failure of the low I.Q. students was twice that of the high I.Q. students. In test four, in which the decrease was 2.65 percent per five I.Q. points, the low I.Q. students had three times the failure of the high I.Q. students. Still, the trend line for test four was considerably lower than for test one.

All but the fifth test showed a negative trend, that is, a decrease in failure with an increase of intelligence. Although a trend line was found for the fifth test, the correlation of only .37 shows that this line does not accurately represent the data. Also in that test, which had fewer than 400 subjects divided into 12 classes, some classes, especially the extremes, were so small that a normal distribution was not probable. It should be realized that there is probably little significance to a difference in scores of five I.Q. points. The change per five I.Q. points is a matter of choosing units.

Analysis by Age

The results were tabulated according to the age of the subjects at the time of the original test (see Table 3). Since only one of the 122 eleven-year-olds had an I.Q below 90, and only two of the 103 girls who were 16 years or

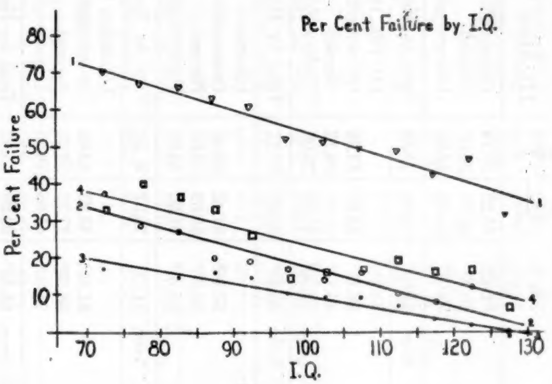

FIGURE I.

TABLE 4.—BREAK-DOWN OF KRAUS-WEBER FAILURES IN EACH PHYSICAL TYPE CATEGORY BY I.Q.

FIRST TEST

AVERAGES BY WEIGHT					TALL			AVERAGE			SHORT		
	Deficient	Flexibility	Weakness	I.Q. Above 120	Deficient	Flexibility	Weakness	Deficient	Flexibility	Weakness	Deficient	Flexibility	Weakness
	71.42[a]	14.28	57.14	Overweight	66.66	0.00	66.66	66.66	33.33	33.33	100.00	0.00	100.00
	36.92[a]	30.76	20.00	Normal	46.66[a]	40.00	33.33	31.25[a]	31.25	9.37	0.00	0.00	0.00
	50.00[a]	43.75	12.50	Underweight	55.55	44.44	11.11	20.00	20.00	0.00	100.00[a]	100.00	50.00
I.Q. Aver.	42.04[a]	34.09	21.59	Total by Height	50.00[a]	38.09	30.95	32.50[a]	30.00	10.00	50.00[a]	33.33	33.33
				I.Q. 110-119									
	50.76[a]	23.07	53.84	Overweight	48.48[a]	15.15	57.57	60.00[a]	32.00	64.00	28.57	28.57	0.00
	44.44[a]	25.39	34.12	Normal	46.72[a]	22.15	42.05	45.45[a]	28.09	28.92	29.16[a]	25.00	25.00
	52.50[a]	45.00	25.00	Underweight	53.33[a]	46.66	13.33	55.00[a]	55.00	30.00	40.00	0.00	40.00
I.Q. Aver.	46.49[a]	36.69	27.17	Total by Height	47.72[a]	23.22	42.58	48.79[a]	31.92	34.33	30.55[a]	22.22	22.22
				I.Q. 90-109									
	57.14[a]	31.42	51.42	Overweight	58.33[a]	27.77	55.55	51.92[a]	23.07	53.84	70.59[a]	64.70	35.29
	50.08[a]	34.69	34.04	Normal	53.73[a]	34.57	40.18	49.50[a]	35.21	32.22	43.75[a]	33.33	26.04
	55.73[a]	41.80	36.06	Underweight	56.52[a]	47.82	39.13	44.64[a]	30.35	32.35	85.00[a]	60.00	45.00
I.Q. Aver.	51.78[a]	35.32	36.51	Total by Height	54.72[a]	35.81	41.89	49.14	33.00	34.71	53.38[a]	41.35	30.07
				I.Q. Below 90									
	81.81[a]	45.45	63.63	Overweight	100.00	25.00	75.00	33.33[a]	33.33	33.33	100.00[a]	75.00	75.00
	58.58[a]	37.37	51.51	Normal	73.68[a]	52.36	73.68	59.57[a]	40.42	48.93	48.48[a]	24.24	42.42
	75.00[a]	41.66	70.83	Underweight	75.00[a]	50.00	75.00	90.00[a]	40.00	110.00	60.00	40.00	30.00
I.Q. Aver.	63.43[a]	38.80	55.97	Total by Height	77.77[a]	48.14	74.07	63.33[a]	40.00	58.03	55.31[a]	31.91	42.55
				TOTALS									
	56.91[a]	28.66	53.19	Overweight	56.57[a]	21.05	57.89	54.21[a]	26.50	55.42	65.51[a]	55.17	34.48
	48.68[a]	32.61	34.85	Normal	52.16[a]	32.43	41.89	48.30[a]	33.73	31.53	41.66[a]	29.48	28.84
	56.93[a]	42.57	36.13	Underweight	56.75[a]	47.29	32.43	50.54[a]	36.26	37.36	72.97[a]	48.64	40.54
	50.80[a]	33.52	37.47	Total by Height	53.46[a]	32.88	42.88	49.33[a]	33.18	35.25	50.00[a]	36.03	31.53

				I.Q. Above 120								
	0.00	0.00	0.00	Overweight	0.00	0.00	0.00	0.00	0.00	0.00	......	......	......
	14.63	9.75	4.88	Normal	5.88	5.88	0.00	23.89	14.37	9.52	0.00	0.00	0.00
	16.66	8.33	8.33	Underweight	0.00	0.00	0.00	20.00	0.00	20.00	100.00	100.00	0.00
I.Q. Aver.	13.79	8.62	5.17	Total by Height	3.84	3.84	0.00	21.42	10.71	10.71	25.00	25.00	0.00
				I.Q. 110-119									
	16.21ᵃ	10.81	13.51	Overweight	18.75ᵃ	12.50	25.00	16.66	11.11	5.55	0.00	0.00	0.00
	17.36ᵃ	7.63	13.88	Normal	27.27ᵃ	14.54	23.60	14.08	4.22	9.85	0.00	0.00	0.00
	30.43ᵃ	26.08	8.69	Underweight	28.57	14.28	14.28	30.76	30.76	0.00	33.33ᵃ	33.33	33.33
I.Q. Aver.	18.62ᵃ	20.29	13.23	Total by Height	25.64ᵃ	14.10	23.07	16.66	8.82	7.84	4.16ᵃ	4.16	4.16
				I.Q. 90-109									
	25.92ᵃ	14.81	14.81	Overweight	19.04ᵃ	14.28	9.52	27.27	9.09	18.18	36.36ᵃ	27.27	18.18
	15.92ᵃ	11.14	6.36	Normal	20.23ᵃ	13.09	8.33	14.91ᵃ	10.49	6.07	12.24ᵃ	10.20	4.08
	20.77ᵃ	18.42	9.21	Underweight	14.28	14.28	0.00	22.72ᵃ	18.18	11.36	27.27ᵃ	18.18	18.18
I.Q. Aver.	18.18ᵃ	12.83	7.88	Total by Height	19.04	13.48	7.14	17.40ᵃ	12.14	8.09	18.30ᵃ	14.08	8.45
				I.Q. Below 90									
	66.66ᵃ	33.33	50.00	Overweight	0.00	0.00	0.00	100.00ᵃ	50.00	100.00	66.66	33.33	33.33
	26.66ᵃ	15.55	17.77	Normal	33.33	16.66	16.66	19.04	9.52	9.52	33.33ᵃ	22.22	27.27
	50.00ᵃ	10.00	50.00	Underweight	0.00	0.00	0.00	71.42ᵃ	14.18	71.42	0.00	0.00	0.00
I.Q. Aver.	34.42ᵃ	16.39	26.22	Total by Height	22.22	11.11	11.11	36.66ᵃ	13.33	30.00	36.36ᵃ	22.72	27.27
				TOTALS									
	23.52ᵃ	13.72	15.68	Overweight	17.07ᵃ	12.19	14.63	25.00ᵃ	11.36	15.90	35.29ᵃ	23.52	17.64
	17.09ᵃ	10.47	9.19	Normal	21.60ᵃ	12.96	12.96	15.64ᵃ	9.18	7.48	13.63	10.22	7.95
	24.79ᵃ	18.18	12.39	Underweight	13.88	11.11	2.77	28.98ᵃ	20.28	15.94	31.25ᵃ	25.00	18.75
	19.16ᵃ	12.12	10.56	Total by Height	19.66ᵃ	12.55	11.71	18.91ᵃ	11.30	9.82	19.01ᵃ	14.04	10.74

[a]Where the total of the percent for flexibility plus the percent for weakness is greater than the percent for deficiency, there are multiple failures.
[b]First and fourth tests were given in September one year apart.

older had I.Q.'s above 110, scores for girls 11 and 12 years old were grouped together, those for girls 13 and 14 years old were tabulated separately, and those for girls who were 15 years and older were recorded in another group, to keep a representative I.Q. distribution.

As the age level of the subjects increased, the percent of Kraus-Weber failure increased and the amount of improvement made decreased.

Analysis by Physical Type and Intelligence

The cards for both the original and the fourth tests were first separated into four I.Q. divisions: I.Q. above 120, I.Q. 110 to 119, I.Q. 90 to 109, and I.Q. below 90. Next, each I.Q. division was grouped according to nine physical type categories: tall-overweight, tall-normal, tall-underweight; average-overweight, average-normal, average-underweight; short-overweight, short-normal, short-underweight. The scores were tabulated for each category by the regular procedure for computing the results of the Kraus-Weber test. Since changes in age, growth, weight gain, or loss caused changes of categories, some girls were not necessarily in the same categories for both tests. The results of this analysis are shown in Table 4.

In a comparison of the results of the first and fourth test, given in September one year apart, the overweight and the tall girls, generally those of higher intelligence, were found to have made the greatest improvement. Weight influenced Kraus-Weber failure to a greater degree than height; in fact, the difference in failure by height was slight, the tall girls failing most frequently both times. Normal weight girls consistently had the lowest failure, and underweight had the highest.

In flexibility the tall-overweight subjects made the best showing on the first test; average-normal made the best showing on the fourth test. However, five other categories were within a 3 percent range difference from the average-normal girls on the fourth test. The short-overweight and the short-underweight had the highest failure in flexibility on both the first and the fourth tests.

In strength the tall-overweight and the average-overweight had the most failures for the first test; in the fourth test the short-underweight had the most. The best showing on strength tests was made by the short-normal girls for the first test, and by the tall-underweight for the fourth test.

Analysis of the Interrelationship of Physical Type and Intelligence

Table 5, presenting the interrelationship of physical type with intelligence, gives the number and percents of testees in each group.

Girls of superior intelligence were generally both heavier and taller than the ones of average or low mental potential; the dull group had the highest percentage of short girls and a high percentage of underweight girls. Except in the small very superior group, as I.Q. increased, the percent of overweight

TABLE 5.—NUMBER OF SUBJECTS IN EACH HEIGHT-WEIGHT CATEGORY

	FIRST TEST								FOURTH TEST							
	Total		Tall		Average		Short		Total		Tall		Average		Short	
I.Q. Above 120																
Overweight	7	7.95%	3		3		1		5	8.62%	3		2		0	
Normal	65	73.86%	30		32		3		41	70.69%	17		21		3	
Underweight	16	18.18%	9		5		2		12	20.68%	6		5		1	
Total by Height	88	6.21%	42	47.73%	40	45.45%	6	6.81%	58	7.56%	26	44.82%	28	48.28%	4	6.89%
I.Q. 110 to 119																
Overweight	65	18.21%	33		25		7		37	18.13%	16		18		3	
Normal	252	70.58%	107		121		24		144	70.59%	55		71		18	
Underweight	40	11.20%	15		20		5		23	11.27%	7		13		3	
Total by Height	357	25.19%	155	43.41%	166	46.50%	36	10.08%	204	26.59%	78	38.23%	102	50.00%	24	11.76%
I.Q. 90 to 109																
Overweight	105	12.70%	36		52		17		53	12.61%	21		22		11	
Normal	611	72.79%	214		301		96		314	70.18%	84		181		49	
Underweight	122	14.50%	46		56		20		77	17.20%	21		44		11	
Total by Height	838	59.14%	296	35.37%	409	48.68%	133	15.94%	444	57.88%	126	28.66%	247	54.82%	71	16.51%
I.Q. Below 90																
Overweight	11	8.20%	4		3		4		6	9.83%	1		2		3	
Normal	99	73.89%	19		47		33		45	75.41%	6		21		18	
Underweight	24	17.91%	4		10		10		10	14.75%	2		7		1	
Total by Height	134	9.45%	27	19.40%	60	46.27%	47	34.32%	61	7.95%	9	14.75%	30	50.82%	22	34.42%
TOTAL																
Overweight	188	13.35%	76	5.37%	83	5.86%	29	2.12%	102	13.30%	41	5.34%	44	5.74%	17	2.22%
Normal	1027	72.44%	370	26.10%	501	35.38%	156	10.96%	544	70.92%	162	21.12%	294	38.33%	88	11.47%
Underweight	202	14.20%	74	5.23%	91	6.43%	37	2.54%	121	15.77%	36	5.69%	69	9.00%	16	2.08%
Total by Height	1417[a]	100.00%	520	36.70%	675	47.67%	222	15.62%	767	100.00%	239	31.15%	407	53.07%	121	15.77%

[a] No height weight data for four girls.

and tall girls increased. This small group of very superior girls had the greatest percent of underweight and tall girls.

The average I.Q. for the fourth test group was slightly higher than for the first test because of the larger drop out among the low I.Q. girls than in the other groups.

Comparison of Kraus-Weber Failures for Differing Physical Education Programs

In Cochran, 227 of the subjects had been given some conditioning exercises 15 months previous to the administration of the first Kraus-Weber test. The results in the tests for girls in that school indicated some carry-over of the effects of their earlier conditioning. Their rate of failure was lower than that of the girls from Garfield, where a very well-conducted, well-organized, well-equipped games program (including archery, badminton, ping-pong, shuffleboard, paddle tennis, darts, folk dancing, nine court basketball, volleyball, and softball) had been the syllabus prior to 1956. The percent difference between the two schools on the first test showed Cochran 17.24 percent lower than Garfield, second test 14.40 percent lower, third test 9.36 percent lower. These results are found in Table 6.

TABLE 6.—A COMPARISON OF KRAUS-WEBER FAILURES FOR DIFFERING PROGRAMS OF PHYSICAL EDUCATION (COCHRAN AND GARFIELD SUBJECTS BY AGE AND INTELLIGENCE QUOTIENT)

	COCHRAN				GARFIELD			
	1st Test	2nd Test	3rd Test	4th Test	1st Test	2nd Test	3rd Test	4th Test
11 Years	47.22	8.33	2.60	14.28	80.00	33.33	20.00	16.66
12 Years	45.91	7.37	4.91	22.77	56.97	22.09	13.95	10.46
13 Years	42.51	8.06	4.91	25.00	53.19	19.14	8.51	11.34
14 Years	40.29	11.20	8.10	26.66	60.78	24.50	15.68	14.70
15 and Older	38.88	8.33	8.33	18.75	71.42	25.00	21.42	21.42
I.Q. 110 Up	36.61	5.54	2.99	23.62	60.00	16.92	6.92	10.00
I.Q. 90-109	42.49	9.09	4.21	22.54	59.29	24.77	16.81	12.83
I.Q. Below 90	64.28	15.00	15.78	42.85	58.06	32.25	16.12	29.03
TOTALS	42.19	8.33	4.06	24.51	59.43	22.73	13.42	13.17
TENTH GRADE[a]								
				Promoted				Promoted
14 Years	17.39	4.34	0.00	......	61.76	32.35	5.88	......
15 Years	32.83	5.97	4.47	......	65.27	26.38	8.33	......
16 Years	17.64	5.88	5.88	......	70.83	37.50	12.50	......
I.Q. 110 Up	15.38	0.00	0.00	......	60.00	20.00	5.71	......
I.Q. 90-109	33.33	9.53	6.34	......	67.46	32.53	9.63	......
I.Q. Below 90	40.00	0.00	0.00	......	66.66	41.66	8.33	......
TOTALS	28.44	6.93	3.33		65.38	30.00	8.46	

[a]Tenth graders included in percentages in top half of this table in tests 1, 2, and 3, are partly responsible for making the Cochran percentages lower than the Garfield's.

Cochran's tenth grade subjects had a difference of failure 26.25 percent lower than that for all the girls of that school; at Garfield the tenth grade subjects had a difference 5.95 percent higher than that for their whole group. However, of those 130 Garfield sophomores, 44 girls had not been in physical education classes until ninth grade, for they had enrolled from township and parochial schools where such education was not in the curriculum. The ones who had been at Garfield the full four years had 56.57 percent failure on the first test, about double that for the Cochran sophomores, but about the same as that reported for the American children in the Kraus-Hirschland study. The Garfield sophomore girls who had enrolled at ninth grade had a failure of 81.63 percent on the first test, a difference of 20.20 percent higher than that for the girls of Garfield as a whole. These figures assume greater significance when we consider the fact that many of the disinterested, over-age, low I.Q. students, who fail the Kraus-Weber test most frequently, have dropped out of school before reaching tenth grade.

Partly as a result of the promotion of the girls having the lowest rate of failure, Cochran's failure increased a difference of 20.45 percent over the summer and Garfield's remained about the same. Since Cochran's conditioning had been concentrated at the beginning of the school year and Garfield had had calisthenics occasionally throughout the semester, including the last month of school, the results showing loss of strength and flexibility over the summer indicate that periodical sessions of calisthenics are necessary for junior high school girls to retain the ability to pass the Kraus-Weber test.

Summary

The Kraus-Weber test was given four times over a period of 15 months to all girls in the required physical education classes of two junior high schools of Johnstown, Pennsylvania. The testing was continued a second semester in the Garfield school, providing results for tests five and six.

A positive correlation was found to exist between intelligence quotient and Kraus-Weber test failures. The trend lines show that as intelligence increased, Kraus-Weber failures decreased. That lack of understanding the test played an important part in failure is doubtful, since the test requires no learning or skill and can be used with pre-school aged children. None of the subjects had mental ages that low. Intelligence had a significant effect on success or failure of the test.

Age also influenced failure of the Kraus-Weber test. As the age level of the subjects increased, the percentage of Kraus-Weber failure increased and the amount of improvement made decreased.

Weight influenced failure to a greater degree than height. In flexibility, the most controversial of the Kraus-Weber subtests (6), the tall-overweight girls failed *less* frequently than the others before conditioning; after conditioning, the average-underweight, short-overweight and short-underweight failed most often. In strength the tall-overweight and the average-overweight had the

highest failure percent on the first test; after conditioning the short-underweight had the greatest. Therefore, the greater height and weight of the American children do not significantly affect their ratings as suggested by some writers.

The effects of the direct attack of a good calisthenics program were significant. Failure on the first test by the Garfield girls, who had never participated in a conditioning program, was 59.43 percent, which is comparable to the results for other American children reported in studies by Dr. Kraus and his associates. The Cochran girls, though they had not had a formal program for 15 months prior to this study, showed some carry-over of earlier conditioning, for their failure rate was only 30.39 percent. A program based entirely on learning and playing games did not produce sufficient strength and flexibility to reduce the Kraus-Weber test failure below the level reported for American children; but, participation in conditioning exercises, twice each week for part of one semester, brought the rate of success for all the girls to that of the European children and, in two semesters, to 5 percent above that European rate.

Although the average Kraus-Weber test failure of American children is 57.9 percent, the results of this research indicate that if junior high school girls who are free from mental and physical disorders participate regularly in physical activities based upon their physiological needs during this age period when strength is built (2), they will pass the Kraus-Weber test.

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Changes in Body Fat, Estimated from Skinfold Measurements of Varsity College Football Players during a Season

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Abstract

A practical way to study changes in body composition, especially body fat, by the use of skinfolds has been demonstrated. Skinfold measurements, abdomen, chest, arm, were made on varsity football players at the beginning and end of a season. Using this information, changes in body composition that occurred during conditioning and training were studied. Body weight did not change significantly, but significant losses occurred from the three skinfold sites. Body density as estimated from skinfold data increased with training and conditioning. Presumably this increase was due to loss of body fat and increase in muscle mass and other bodily components.

FOOTBALL ON THE UNIVERSITY LEVEL generally attracts individuals of massive muscular structure and weight. It is not uncommon for university varsity lines to average more than 200 pounds per man. The nature of the game requires superbly conditioned athletes who can endure the bruising bodily contact of blocking and tackling as well as hard running and jumping. This study is concerned with the changes and variations, if any, in the bodily composition that occurs in a university varsity football squad during a season of participation.

Except for certain anthropometrical measurement changes, little is known about the changes in body composition associated with conditioning and training. Thompson, Buskirk, and Goldman (10) found that body fat, particularly subcutaneous fatness, was altered by a season of strenuous training in both varsity college basketball and hockey players. Body weight loss was not significant, but skinfold measurements of abdomen, chest, and upper arm all decreased significantly. Body density estimated from skinfold measurements increased, thus indicating a loss of body fat which has a lower density than muscle. Also, body fat estimated from skinfold measurements was less at the end of the season in both basketball and hockey players.

One of the first studies of body composition involving athletes was conducted by Welham and Behnke (11) in 1942. They found that professional football players had a larger "lean body mass" than average Navy men although the mean specific gravity values were not significantly different. Buskirk (2) found that wrestlers and cross-country runners had higher body densities and less fat than average college students.

Tanner (9) studied the development of ten "Mesomorphic" young men who were under the guidance of a professional weight lifter for four months. A significant increase of approximately 2 cm. in upper arm circumference was observed with essentially no change in the skinfold measurements over the front and back of the upper arm. Similar changes were not found in the leg.

A recent (1955) study (8) performed on paratroopers is one of the most extensive to date. Body composition was studied before and after paratroop training. The average loss in body weight was only 0.6 kg., and a small but significant increase occurred in body density as measured by underwater weighting. Body fat had decreased significantly.

Methods and Procedures

Skinfold calipers and measurement techniques have undergone considerable improvement in recent years. Now constant tension calipers are available which make possible more accurate and reliable measurements. Baker (1) found $r = .95$ between skinfold caliper readings over the arm and thigh and measurements of skin plus fat thickness from roentgenograms. In a similar study of the comparison of pinch caliper and x-ray measurement at the level of the lowest rib Garns (5) found $r = .88$ with 65 young men 21 to 26 years old.

When measurements are made, skinfold calipers should have a recommended pressure of at least 10 gm/mm^2 between the jaw faces in order to secure reliable measurements. The measured skinfold thickness is highly dependent on caliper pressure until at least 10 gm/mm^2 is reached.

Since intercorrelations between skinfolds measured at various sites are high (0.7-0.95) only a few site measurements are necessary (4). Abdomen, chest, and upper arm skinfold measurements have good predictive value and can be readily measured on the average male.

The Vernier Caliper modified at the Laboratory of Physiological Hygiene, University of Minnesota, was used in this study for the measurement of skinfold thickness. The pressure exerted between the jaw faces of the calipers was the recommended 10 gm/mm^2.

The skinfold measurement sites were:

1. Abdomen—approximately 5 cm. to the right of the umbilicus (skinfold oriented laterally).
2. Chest—about 5 cm. from the right nipple on a line toward the uppermost point of the axillary fold (skinfold parallel to this line).
3. Upper arm—over the right triceps, halfway between the olecranon and acromial processes (skinfold parallel to the long axis of the arm).

In making a measurement, the skinfold was lifted with the thumb and index finger and held while the caliper was applied approximately 1-1.5 cm. away. Care was taken to exceed the standard pressure before the measurement was made in order to reduce the early changes in thickness thought to occur with fluid shifts.

TABLE 1.—SKINFOLDS, WEIGHT CHANGES AND CHARACTERISTICS OF VARSITY FOOTBALL PLAYERS DURING A SEASON OF PARTICIPATION

No.	Age	Height (cm.)	Weight (Kg.) Before	Weight (Kg.) After		Abdominal B	Abdominal A		Chest B	Chest A	Kg. Difference	Upper Arm B	Upper Arm A	
1	22	168.75	80.681	80.454	− .277	17	13	−4	8	7	−1	10	8	−2
2	22	173.75	89.318	83.863	−5.455	19	11	−8	8	5	−3	7	7	0
3	23	176.25	87.272	85.227	−2.045	9	8	−1	8	5	−3	6	6	0
4	20	178.75	89.091	86.590	−2.501	16	15	−1	7	5	−2	10	9	−1
5	22	171.25	71.704	71.363	− .341	10	5	−5	5	5	0	5	5	0
6	22	180.625	85.454	85.454	0	10	8	−2	7	4	−3	7	8	+1
7	20	176.875	99.659	95.454	−4.205	29	21	−8	13	10	−3	14	13	−1
8	20	179.375	100.227	99.090	−1.137	26	23	−3	19	13	−6	14	17	+3
9	21	182.5	91.477	89.545	−1.932	24	14	−10	13	8	−5	15	13	−2
10	21	167.5	84.090	80.000	−3.090	19	7	−12	13	5	−8	11	8	−3
11	22	173.75	85.454	84.318	−1.136	16	15	−1	11	4	−7	7	7	0
12	21	176.875	85.227	81.818	−3.409	24	16	−8	10	8	−2	13	12	−1
13	19	176.25	87.727	86.818	− .909	21	16	−5	13	10	−3	8	7	−1
14	20	179.375	84.340	85.000	+ .660	25	14	−11	12	7	−5	19	16	−3
15	20	170.625	83.750	83.409	− .341	24	16	−8	12	7	−5	14	16	+2
16	21	180.625	73.863	80.454	+6.591	5	7	+2	4	4	0	5	6	+1
17	22	188.125	104.545	102.045	−2.500	13	10	−3	7	4	−3	7	7	0
18	22	178.125	90.227	88.636	−1.591	18	16	−2	15	7	18	15	8	−7
19	19	173.75	96.590	93.181	−3.409	28	19	−9	17	11	−6	15	13	−2
20	20	174.375	87.272	84.772	−2.500	26	11	−15	10	4	−6	12	9	−3
21	19	179.375	86.818	86.818	0	21	22	+1	16	10	−6	12	11	−1
22	23	175.625	88.750	86.363	−2.387	26	15	−11	16	12	−4	16	10	−6
23	22	176,875	77.954	80.909	+2.955	9	9	0	8	5	−3	8	9	+1
24	19	177.5	102.272	100.454	−1.818	24	12	−12	14	8	−6	8	7	−1
25	21	183.75	85.909	85.454	− .455	16	12	−4	12	6	−6	12	12	0
26	21	180.00	83.181	79.545	−3.636	25	12	−13	15	5	−10	11	10	−1
27	27	180.625	93.181	94.090	+ .909	29	28	−1	11	9	−2	14	9	−5
28	21	196.25	95.454	92.500	−2.954	16	8	−8	14	5	−9	8	8	0
29	20	179.375	91.022	84.090	−6.932	22	10	−12	13	5	−8	11	9	−2
30	21	178.75	101.137	100.681	− .456	28	30	+2	24	13	−11	16	13	−3
31	19	180.00	86.363	86.818	+ .455	12	12	0	8	5	−3	14	11	−3
32	21	175.625	85.909	85.000	− .909	24	15	−9	13	10	−3	14	10	−4
33	20	172.5	91.818	91.363	− .455	20	16	−4	14	7	−7	12	12	0
34	19	177.5	91.818	87.272	−3.546	26	15	−11	14	8	−6	17	12	−5
M		177.68	88.81	87.32		19.91	14.15		11.88	6.94		11.38	9.94	
σ		5.54	8.04	8.53		6.71	8.11		4.74	2.76		4.64	2.99	
t				1.03[a]				4.47[b]			10.8[b]			6.69[b]

[a] Nonsignificant difference.
[b] Significant difference at 1 percent level.

Each skinfold was lifted and measured three times. The results reported are the average of the three measurements. Body weight was measured on the Standard Physician's Scales.

The initial measurements were made the last week of August when the squad took physical examinations prior to the beginning of football practice. The final measurements were made the last week of football practice, approximately 12 weeks after the first.[1]

Results

The 34 varsity college football players in this study had the following mean characteristics: 20.9 years, height 177.7 cm. (71.7 inches), and weight 88.8 kg. (195 lbs.) at the beginning of the training and condition period for the season.

The body weight changes during the season are shown in Table 1. The mean weight loss was 1.49 kg. (3.3 lbs.), which was not significant (7). Twenty-seven of the 34 players lost weight ranging from .2 kg. (less than one-half pound) to 6.7 kg. (approximately 15 lbs.). Two players had no weight change and five gained weight.

A comparison of skinfold measurements indicated that a redistribution of weight had occurred (Table 1). Subcutaneous fat had been utilized and presumably muscle mass and/or other bodily components increased. The most pronounced skinfold changes occurred in the largest skinfold, the abdominal fold. The mean decrease was 5.76 mm. which was significant at the 1 percent level (7). The chest and upper arm skinfolds were significantly smaller at the end of the season: chest —4.94 mm. and upper arm —1.44 mm. All three skinfold sites decreases were significant at the 1 percent level. These results are in agreement with other studies (10). The larger the skinfold the greater is the loss or increase with weight changes. Correlations between skinfold measurements (before) were relatively high; abdomen and chest $r = .84$, abdomen and arm $r = .79$, chest and arm $r = .88$.

Body density was calculated using the regression equations formulated by Brozek (4) from the original work of Brozek and Keys.

Equations for Predicting Body Density (Combined Skinfolds)

Formula: $\hat{Y} = a\text{-}bx\text{-}c\mu$

Skinfold	a 1.0951	b, c (mm)
Abdomen		0.00028
Chest		0.00073
Upper Arm		0.00088

[1]Appreciation is expressed to members of the Boston University varsity football squad and to Mr. Buff Donelli and his coaching staff for their cooperation in this study.

TABLE 2.—INDIVIDUAL AND MEAN CHANGES OF BODY WEIGHT, ESTIMATED BODY DENSITIES, PERCENT FAT AND FAT OF VARSITY FOOTBALL PLAYERS DURING A SEASON

Subject	Weight B	Weight E	Density B	Density E	Per Cent Fat B	Per Cent Fat E	Fat B	Fat E
1	80.681	80.454	1.0822	1.0839	6.53	6.28	5.27	5.05
2	89.318	83.863	1.0835	1.0865	6.42	5.35	5.73	4.49
3	87.272	85.227	1.0860	1.0877	5.53	4.93	4.83	4.20
4	89.091	86.590	1.0826	1.0846	6.74	6.03	6.01	5.22
5	71.704	71.363	1.0878	1.0869	4.89	5.21	3.51	3.72
6	85.454	85.454	1.0857	1.0869	5.63	5.21	4.81	4.45
7	99.659	95.454	1.0733	1.0764	10.10	8.98	10.07	8.57
8	100.227	99.090	1.0660	1.0756	12.79	9.27	12.82	9.19
9	91.477	89.545	1.0756	1.0809	9.27	7.35	8.48	6.58
10	84.090	80.000	1.0749	1.0827	9.52	6.71	8.01	5.37
11	85.454	84.318	1.0827	1.0862	6.71	5.46	5.73	4.60
12	85.227	81.818	1.0781	1.0819	8.36	6.99	7.14	5.72
13	87.727	86.818	1.0806	1.0831	7.46	6.56	6.54	5.70
14	84.340	85.000	1.0734	1.0777	10.07	8.51	8.49	7.23
15	83.750	83.409	1.0766	1.0826	8.90	6.74	7.45	5.62
16	73.863	80.454	1.0894	1.0880	4.32	4.82	3.19	3.88
17	104.545	102.045	1.0852	1.0872	5.81	5.48	6.07	5.59
18	90.227	88.636	1.0756	1.0834	9.27	6.46	8.36	5.73
19	96.590	93.181	1.0686	1.0785	11.83	4.99	11.43	4.65
20	87.272	84.772	1.0784	1.0858	7.26	5.60	6.34	4.75
21	86.818	86.818	1.0763	1.0797	9.02	7.78	7.83	6.75
22	88.750	86.363	1.0730	1.0860	10.21	5.53	9.06	4.76
23	77.954	80.909	1.0821	1.0823	6.92	6.85	5.39	5.54
24	102.272	100.454	1.0785	1.0849	7.86	5.92	8.04	5.95
25	85.909	85.454	1.0793	1.0818	7.93	7.03	6.81	6.01
26	83.181	79.545	1.0767	1.0840	8.87	6.25	7.38	4.97
27	93.181	94.090	1.0748	1.0802	9.56	7.61	8.91	7.16
28	95.454	92.500	1.0806	1.0858	7.46	5.60	7.12	5.18
29	91.022	84.090	1.0782	1.0868	8.33	5.25	7.58	4.41
30	101.137	100.681	1.0688	1.0738	11.75	9.93	11.88	10.00
31	86.363	86.818	1.0807	1.0852	6.43	5.82	5.55	5.05
32	85.909	85.000	1.0763	1.0816	9.02	7.11	7.75	6.04
33	91.818	91.363	1.0775	1.0817	8.58	7.07	7.88	6.46
34	91.818	87.272	1.0701	1.0814	11.28	7.17	10.36	6.26
Mean	88.81	87.32	1.0782	1.0829	8.25	6.53	7.41	5.73
S.D.	8.04	8.53	.0172	.0122			2.17	1.76

The mean body density before practice was 1.0782 (Table 2) and at the end of the season 1.0829. An increase in body density indicates a change in bodily components. As body fat decreases and muscle fibers and other bodily components increase, the density increases. Conversely, when the body fat increases the density of the body will decrease, as body fat has a lower specific gravity than even body water.

Individually, 32 of the 34 players showed increases in body density with football conditioning training (see Table 2). Generally, the increase in density was in direct proportion to the loss of weight. Exceptions were subjects 5 and 16, who did not have an increase in body density. Subject 5 gained one-half kg. (1 lb.), and subject 16 gained approximately 7 kg. (more than 15 lbs.), most of which was apparently body fat.

Total body fat in proportion to the other bodily components was estimated using the equation of Keys and Brozek (6). It is computed from body density using the following formula:

$$F = \frac{4.201}{D} - 3.813$$

This result is expressed as a percent (Table 2). Multiplying the percent of estimated body fat by the body weight of the individual gives the total amount of estimated body fat in kilograms. A correlation between body weight and estimated body fat (before) was $r = .59$. This rather low correlation illustrates the fact that an individual can be heavy (weight) and not have excessive fat.

Weight alone is of limited value in assessing body composition. Frequently football players have massive bony and muscular structures without excessive fat. Subject 17 is the best example found in this study. His weight was approximately 210 lbs., but the estimated body fat was less than 75 percent of the other subjects. Subject 24 is another good example. Individuals of this type would be considered overweight by standard weight charts. In contrast there are several subjects in this study who are heavy (weight) and have high amounts of estimated body fat: subjects 8, 19, 30.

All of the subjects in this study with the exception of three (subjects 5, 16, 23) lost in estimated body fat during the season (Table 2). Subject 5 had a slight increase in body weight; subject 16 gained approximately 15 lbs., much of which was stored as body fat; subject 23 gained approximately 7 lbs. with an increase in total body fat but not in percent of body fat. In contrast, subject 14 gained weight but had a decrease in estimated body fat; the increase in weight was presumably largely muscle mass.

The mean estimated body fat decreased from 7.41 kg. to 5.73 kg. for the 34 subjects.

Summary and Conclusions

Again the practical use of skinfolds to determine changes in body composition associated with conditioning and training has been demonstrated. Three skinfold measurements, abdomen, chest, and arm, of varsity football players before and at the end of the season of intercollegiate competition were made to study changes in bodily composition that occur with conditioning and training.

Body weight did not change significantly but significant losses occurred from the three skinfold sites (abdomen, chest, and arm). Body density determined from skinfold measurements increased with the loss of body fat. Body composition was changed with conditioning and training in the varsity university football players in this study, presumably with an increase in muscle mass and other bodily components.

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Motor Ability and Educability Factors of High and Low Scoring Beginning Bowlers [1]

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Abstract

Forty-one college women who had never bowled were tested for motor ability, educability, and body sway, and were also given the ACE and finger test. The means and standard deviations of the beginning levels of bowling ability and of all tests were computed. For each test, those who were one standard deviation or more above or below the mean were analyzed on the scores for all other tests. On the basis of this analysis the following conclusions appear justifiable. The above average bowler is better in motor ability and educability than the below average bowler. The above average scorer on the educability test has significantly less body sway and significantly higher bowling scores than the below average scorer. Subjects with above average scores in body sway are higher in motor ability and educability than subjects with below average scores in body sway. There is a significant correlation coefficient between the finger and the ACE Test.

THE ABILITY to achieve initial success in a skilled activity is, no doubt, dependent upon many factors. When practice is controlled, there must be certain abilities which differentiate the successful from the nonsuccessful performer. These abilities would conceivably vary at higher levels of learning. However, an analysis of motor ability and educability factors of high and low scoring beginning bowlers can provide a greater insight into abilities influencing initial success in sport activities. Studies have shown the differences in various abilities between the athlete, or skilled player, and the nonathlete, or nonskilled performer.

This study is an attempt to determine the abilities of individuals who, with the same amount of practice, attain beginning success or failure in a fairly simple gross motor activity, such as bowling. The study purposes to analyze the motor ability and educability factors of bowlers who are above average and below average in beginning bowling ability.

Definition of Terms

Motor ability refers to achievement in basic motor skills.

Motor educability pertains to the inherent aptitude (motor and mental) of learning new skills easily and quickly. It is not dependent upon strength and speed.

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[1] This study was supported in part by funds from the Research Council, Florida State University.

Procedure

SUBJECTS

Forty-one freshmen and sophomore college women who enrolled in a beginning bowling class and who had never bowled were the subjects of this study. They were all taught by the investigator, and outside practice was prohibited. They were all tested for motor ability, educability, and body sway, and were also given the ACE and finger test.

TESTS

Motor Ability. The Scott Motor Ability Test was used (9). The short battery consisting of the basketball throw for distance, the broad jump, and the obstacle race was used.

Educability. The "pure" motor educability factors of the Johnson Educability Test, as devised by Metheny (7) were used. She suggested a combination of 3 (stagger jumps) + 2 (stagger skips) + 2 (straddle jumps) + (jumping half-turns) — 25. She found this to predict the motor educability factor in the Johnson Test with a multiple correlation coefficient of .88. A coefficient of reliability of .97 for the entire test was reported.

Body Sway. Body sway in the dorsal ventral plane, with eyes open, was measured for one minute. Recordings were taken every three seconds by direct readings on a scale, and the largest deviation was recorded (4). Sway has been found to be greater in this position than in the lateral position, and therefore, was used because of its possibility of greater differentiation (5, 8). A smaller score signifies less body sway and will be referred to as above average body sway. The coefficient of reliability of the group found by the test re-test method was .84.

Finger Test. Fingers were numbered one to five, and hands were placed in a crossed position on a typewriter. The scoring consisted of the correct responses of the fingers of both hands to 50 randomized commands recorded on an audio tape recording and given every 1½ seconds. Coefficient of reliability by the odd-even method on 100 subjects was .84, with a .91 when stepped up by the Spearman Brown Prophecy Formula.

American Council on Education Psychological Examination (ACE). The ACE scores were taken from the personnel records since all incoming students are required to take this test. The ACE is predictive of college success and is used here as an indication of intelligence and analytical reasoning.

Bowling Ability. Bowling ability was determined by computing the average of the first five lines bowled. Coefficient of reliability on 125 beginning bowlers as determined by the odd-even method was .82.

Treatment of Data

The means and standard deviations were computed for bowling ability and for all of the tests. On the basis of this, those who were one standard devia-

tion or more above the mean in each test were classified as above average, and those who fell one standard deviation or more below the mean were termed below average. Subjects who fell into these groups were then ana-

TABLE 1.—INTERCORRELATIONS OF TESTS

Tests	1	2	3	4	5	6
1. Bowling						
2. Motor Ability	.47					
3. Educability	.32	.28				
4. Body Sway*	—.22	—.23	—.32			
5. ACE	—.17	.05	.12	.14		
6. Finger	—.11	.11	.11	.06	.50	
M	81.32	51.98	36.17	14.54	47.42	35.17
S.D.	13.52	6.70	9.99	6.00	26.25	14.01
N-41						

* A negative correlation in body sway means that the good performer on other tests had less body sway (above average ability) than the poor performer.

TABLE 2.—SCORES ON TESTS OF THOSE WITH ABOVE AVERAGE AND BELOW AVERAGE BOWLING ABILITY

	Motor Ability	Educability	Body Sway	ACE	Finger
Good Bowlers					
M	58.50	41.87	11.50	39.50	35.50
SD	5.24	7.45	3.90	22.40	14.07
N	8				
Poor Bowlers					
M	47.12	30.88	16.50	45.75	37.62
SD	7.27	12.29	14.32	27.56	7.14
N	8				
Diff.	11.38	10.99	5.00	6.25	2.12
σ M Diff.	3.39	5.44	5.61		
t	3.356*	2.02	0.89		

* Significant at better than the 1 percent level of confidence.

TABLE 3.—SCORES ON TESTS OF THOSE WITH ABOVE AVERAGE AND BELOW AVERAGE MOTOR ABILITY

	Bowling	Educability	Body Sway	ACE	Finger
Good Motor Ability					
M	86.57	36.00	15.14	44.14	38.57
SD	18.60	8.38	5.60	19.67	9.89
N	7.				
Poor Motor Ability					
M	75.33	38.22	19.22	41.77	29.00
SD	9.70	11.40	7.00	25.67	
N	9.				15.10
Diff.	11.24	2.22	4.08	2.37	9.57
σ M Diff.	7.64		3.43		6.99
t	1.47		1.189		1.369

lyzed on the scores they made on all other tests. Table 1 gives the means and standard deviations and intercorrelations of the tests. Tables 2 through 7 give the analyses of those who are above average and below average in the various tests.

Results

From Table 2 it is apparent that the above average bowler was significantly higher in motor ability than the below average bowler. This difference was significant at the 1 percent level of confidence. The difference of 10.99 in educability between the two groups, while not significant, was approaching significance (6 percent level of confidence). The difference of 5 points in body sway in favor of the above average bowler did not reach statistical significance.

A comparison of above average and below average subjects in motor ability reveals that the above average performer had better scores on all tests except the one for educability (Table 3). No differences, however, reached statistical significance.

Subjects with above average educability were significantly better in bowling and body sway than the below average subject in educability (Table 4).

TABLE 4.—SCORES ON TESTS OF THOSE WITH ABOVE AVERAGE AND BELOW AVERAGE EDUCABILITY

	Bowling	Motor Ability	Body Sway	ACE	Finger
Good Educability					
M	87.37	52.50	11.87	57.12	42.37
SD	14.66	7.41	2.47	19.59	6.26
N	8				
Poor Educability					
M	70.71	50.71	18.71	47.28	38.28
SD	13.37	5.33	7.21	27.29	10.53
N	7				
Diff.	16.66	1.79	6.84	9.84	4.09
σ M Diff.	7.71	3.57	2.87	12.87	4.67
t	2.160[a]	0.50	2.383[a]	0.764	0.875

[a] Significant at better than the 5 percent level of confidence.

A study of Table 5 shows that subjects with above average body sway were significantly higher in motor ability and educability than those with below average body sway. The difference of 13.72 in the bowling scores was not statistically significant.

The highest coefficient of correlation found between any two tests was between the finger and the ACE Tests (Table 1). Those who were above average in the finger test had a mean which fell in the 71st percentile in the ACE Test, while those who were below average on the finger test had a mean which was in the 23rd percentile. This difference was significant at the 1 percent

TABLE 5.—SCORES ON TESTS OF THOSE WITH ABOVE AVERAGE AND BELOW AVERAGE BODY SWAY

	Bowling	Motor Ability	Educability	ACE	Finger
Good Sway					
M	80.88	53.78	38.22	35.11	35.22
SD	16.31	5.67	8.91	27.58	13.38
N	9				
Poor Sway					
M	67.16	46.50	26.33	48.00	36.33
SD	13.45	5.93	10.54	23.91	16.34
N	6				
Diff.	13.72	7.27	11.85	12.87	1.11
σ M Diff.	8.49	3.27	5.34	14.62	
t	1.616	2.223[a]	2.226[a]	0.88	

[a] Significant at better than the 5 percent level of confidence.

TABLE 6.—SCORES ON TESTS OF THOSE WITH ABOVE AND BELOW AVERAGE ACE

	Bowling	Motor Ability	Educability	Sway	Finger
Good ACE					
M	83.75	51.62	38.75	15.12	42.37
SD	11.87	5.76	10.91	4.22	8.88
N	8				
Poor ACE					
M	78.80	49.00	35.10	14.90	25.0
SD	11.91	5.51	8.70	5.37	15.19
N	10				
Diff.	4.95	1.62	3.65	0.22	17.37
σ M Diff.	5.92	2.80	4.84		6.36
t	0.836	0.57	0.754		2.731[a]

[a] Significant at better than the 2 percent level of confidence.

TABLE 7.—SCORES ON TESTS OF THOSE WITH ABOVE AND BELOW AVERAGE FINGER SCORES

	Bowling	Motor Ability	Educability	Sway	ACE
Good Finger					
M	79.71	54.00	37.71	15.57	70.57
SD	7.30	4.84	8.04	7.98	18.76
N	7				
Poor Finger					
M	88.25	53.00	32.28	14.50	22.75
SD	13.19	7.30	4.96	5.22	5.04
N	8				
Diff.	8.54	1.00	5.43	1.07	47.82
σ M Diff.	5.94		3.71		7.31
t	1.43		1.463		6.54[a]

[a] Significant at better than the 1 percent level of confidence.

level of confidence. When those with above average scores on the ACE Test were analyzed on the finger test, they were found to have a mean score of 42 as contrasted to the mean score of 25 for those who scored below average. This difference was significant at the 2 percent level of confidence.

Discussion

Motor learning in gross motor activities, at beginning levels of learning, is probably more dependent upon inherent physical make-up, strength, speed, and past experiences in sports than upon intelligence and analytical reasoning. For the most part this was found to be true in this study. The good bowler was one standard deviation above the mean of the entire group in motor ability, and one-half a standard deviation above the mean in educability and in body sway. She was no better than the entire group in her scores on the finger and the ACE Tests.

The educability test involves dynamic balance, the kinesthetic memory of a correct motor pattern, and concentration of what is expected in the test. Subjects with above average performance in the educability test were one-half a standard deviation above the mean of the group in bowling, body sway, and the finger test and were one-third sigma above the mean in the ACE Test. The coefficient of correlation of .32 between educability and bowling is due in part, no doubt, to the ability to remember and to execute a simple motor pattern.

Body sway is a measure of static balance, which is controlled, according to most authorities, at the brain stem and cord level and is apparently not amenable to training (3, 13). The results as shown in Table 5 suggest that poor body sway is perhaps more of a handicap in various aspects of motor proficiency than good body sway is an advantage.

Success in the finger and the ACE tests depends, in part, upon the ability to concentrate and to work rapidly. The fingers and thumb have the largest representation in the cortex of any part of the body, and fine use of the fingers is a skill dependent upon cortical integrity. The finger test involves the ability to use each finger in as differentiated a manner as possible and demands an awareness of the subject as to her right and left side. The hands are crossed and this places a greater responsibility on discriminatory powers between right and left. Not only does the subject have to make a motor response but she has to transpose sensory cues into motor responses at a constant rate of one every 1½ seconds. This is enough time for the movement to be executed and for impulses to travel up to the brain and back again. Therefore, any lag in delay is at the cortical level and is a result of faulty integration. The test is in the process of being improved.

In another study a correlation between the finger test and intelligence quotients on 93 subjects gave a coefficient of correlation of .43 (12). Results to date, therefore, point to its possibility as a prognosticator of learning ability.

Conclusions

Results in this study appear to justify the following conclusions.

1. There is a low but significant coefficient of correlation between the following tests or abilities:
   a. Bowling and motor ability
   b. Bowling and educability
   c. Educability and body sway
   d. Finger and ACE
2. Subjects with above average ability in educability are significantly better in bowling and body sway than below average subjects in educability.
3. Subjects with above average ability in body sway are significantly higher in motor ability and educability than below average subjects in body sway.

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Quickness of Reaction and Movement Related to Rhythmicity or Nonrhythmicity of Signal Presentation[1]

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Abstract

When a series of rhythmic signals was presented, with equal probability that any one of them might be accompanied by a stimulus to react, the average reaction time (.20 sec.) was 6 percent faster than when the signals were nonrhythmic. However, the time (also .20 sec.) required for the standardized arm movement which was initiated by the reaction, as well as the "unison" or variability between subjects, showed no rhythmicity effect. Theoretical explanations involved readiness-foreperiod relationships. Individual differences in quickness of reaction and quickness of movement were nearly independent of each other ($r = .31$), although the reliability coefficients were fairly high, namely .89 for reaction and .96 for movement. These results were held to influence application to athletics. The sample size was $N = 50$ (college men); there were 70 trials per subject.

STUDENTS OF the game of football have for many years held two different opinions concerning the value of rhythmic vs. nonrhythmic presentation of the signals called by the quarterback. The advocates of the rhythmic system argue that the use of rhythmic presentation of signals will produce a shorter and more uniform latent period, because the athlete has high readiness to react at specific times and will therefore be able to make a faster response. Those who favor the nonrhythmic system of initiating movement contend that with this system each player will learn to maintain a more alert condition because he does not know exactly when the stimulus will come.

Critical Review

Thompson, Nagle, and Dobias (11) have recently reviewed the literature pertinent to this problem. They have also reported their own experiments, which, in the case of college students, showed a combined reaction and movement time of .51 sec. with rhythmic stimulus presentation and .56 sec. using the nonrhythmic system. The standard deviation was .06 sec. The improvement, nearly 10 percent, was statistically significant.

A critical evaluation of the experiments by Thompson *et al.* raises a question concerning the adequacy of their method, since the experimenter started the chronoscope manually, simultaneously with his verbal presentation of the

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[1]From the research laboratory of the Department of Physical Education, University of California. The writer is indebted to Dr. Franklin M. Henry for advice and encouragement.

starting signal, rather than using some kind of key or switch that would ensure mechanically that stimulus and chronoscope started simultaneously. While it is difficult to avoid this uncertainty as to the involvement of the experimenter's own reaction time with that of the subject, it nevertheless represents a possible uncontrolled element that restricts the interpretation of the results. Another factor that restricts interpretation is the inclusion of both reaction and movement times in a single score. Thompson *et al.* justify this on the grounds that their review of the literature relating reaction time to athletics suggests that the combined score is "a more useful type of reaction time." No reference is made to the several studies which have shown that reaction time and movement time are in general independent and uncorrelated (4, 5), although they do state in their discussion that further work to separate these two factors is projected.

Another study of football charging time, defined as reaction time plus a 12 inch forward movement of the entire body mass, under nonrhythmic conditions, reported the mean as .39 sec. and the standard deviation as .03 sec. (8). With the body already in motion, it would require only .07 sec. for the additional six inches as in the Thompson experiment (5). The average time (including reaction time) required to clear both the forward and the rear foot from starting blocks spaced 18 inches or more apart has been reported as only .33 sec. in one study (3) and .50 sec. in another (5). This act involves considerably more movement than the football charge, which includes only one step to contact the timing plate. Therefore, it definitely seems possible that the rather slow charging time of .57 sec. found by Thompson *et al.* may have included a part of the reaction time of the experimenter; he may have pressed his switch prematurely.

Problem Investigated

In order to avoid the complexities and uncontrollable aspects introduced by the use of a practical situation, with the quarterback (experimenter) calling signals used in football and the subject responding with a football charge, it was decided to focus on the basic principles involved in the problem, using such methods as seemed best adapted to its solution. The resulting experiment utilized light flashes instead of verbal commands and used a simple arm movement as the motor action. The variables under study were rhythmic vs. nonrhythmic stimulus presentations, evaluated as to the effect on net reaction time and net movement time. A secondary problem concerned determination of the correlation between net reaction time and net movement time, when the movement was arranged so that it required the same average time as the reaction.

Methodology

Apparatus. Two chronoscopes read to .005 sec. were used. The variable error, checked several times during the experiment, was .0066 sec. The experimenter's control key (noiseless) flashed on the neon stimulus light, which

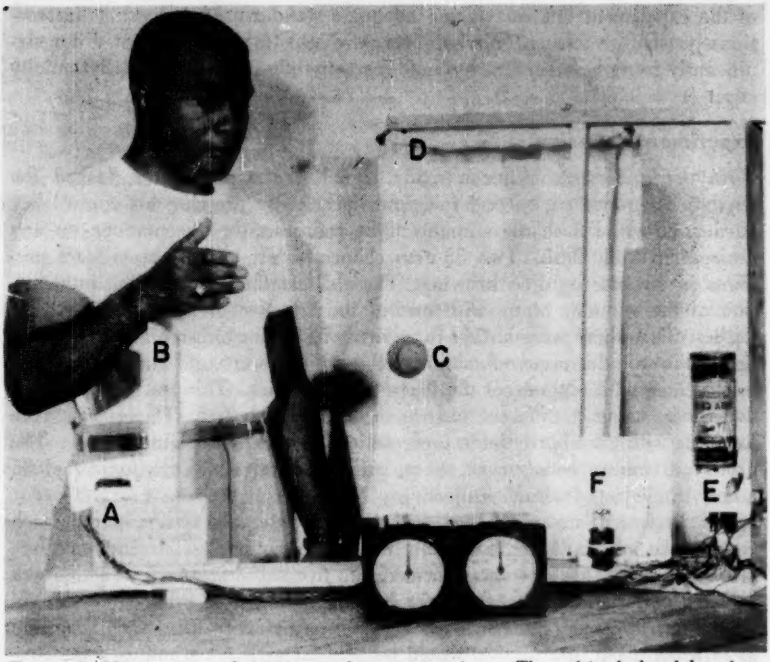

FIGURE I. Measurement of reaction and movement times. The subject's hand has just left the reaction key A, going up and over the barrier B to strike the ball C, opening the circuit at the friction contact D. Rhythmicity signals flash at E; the stimulus to react is given by the neon light F.

action automatically started the first chronoscope. The subject reacted by lifting his finger from the reaction key and swinging his hand and arm upward 12 inches and forward 24 inches to strike vigorously a tennis ball suspended on a string held up by a friction type electrical contact (Figure I). The ball was caught on the rebound by a heavy towel hung behind it. The subject's reaction key was a double contact microswitch. When his finger left it, the reaction time chronoscope stopped and the movement chronoscope started. The latter was stopped when the tennis ball was struck, causing the friction contacts to open.

A "rhythm" light, placed next to the neon stimulus light and in the direct line of vision, permitted the experimenter to present either rhythmic or nonrhythmic cadence flashes, as will be explained. The interval between these flashes was controlled manually by the experimenter, using a continuously running stop watch.

Subjects. Fifty male university students were given the complete series of tests. Most of them (80%) were physical education majors; the rest were student volunteers from activity classes. They were not told the real purpose

of the experiment but were given adequate standardized individual instructions just before testing. Ten subjects were athletes; they did not differ significantly from the others in rhythmic reaction time ($t = 1.14$) or rhythmicity effect ($t = 0.59$).

Experimental Design

Rhythmic Pattern. After a ready signal, the experimenter flashed the rhythm light once per second for eight flashes. By pressing his control key harder, he could flash the stimulus light and start the chronoscope on any desired rhythmic flash. Two 35-item chance order control sheets were prepared in advance by dice-throwing. These determined the random introduction of the stimulus along with one of the last five of the eight rhythmic flashes. Thus there were always three or more flashes to establish the rhythm before the stimulus occurred, although the subjects were told that the stimulus might come with any one of the flashes in the series. This test was repeated five times, using a different chance order for each test. Then there were five tests with the nonrhythmic presentation, as will be explained below. The procedure was repeated seven times, giving a total of 35 rhythmic and 35 nonrhythmic tests for each subject.

Nonrhythmic Pattern. A series of 40 flash intervals was prepared, each consecutive interval being randomly chosen from the possible intervals 0.5, 1.0, or 1.5 sec. This series was divided into five subseries, each of which was called a pattern. The patterns were used in consecutive order for the nonrhythmic trials, each pattern being repeated after every fifth trial. Decision as to which flash in a pattern would be coupled with the stimulus was determined by the same control sheets that were used for the rhythmic presentation. Some modification of true chance order was made in the patterns to ensure that short nonrhythmic sequences prior to the stimulus were not inadvertently rhythmic.[2]

Balancing of Orders. Odd-numbered subjects were assigned control sheet A for the rhythmic and sheet B for the nonrhythmic presentation. The order of use of A and B was reversed for the even-numbered subjects. Half of the 50 subjects were first tested under the rhythmic and half under the nonrhythmic condition, so as to balance out the influence of practice or fatigue. The total number of trials per subject was 70, half under the rhythmic conditions and half under the nonrhythmic, alternating the two when each subseries of five trials per condition was completed. All 70 trials were done in a single test session.

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[2]Following are examples of rhythmic and non-rhythmic patterns. The intervals are given in seconds; the "hot" stimulus is in each case identified by an asterisk.

1.0	1.0	1.0	1.0*	1.0	1.0	1.0	1.0
1.0	1.0	1.0	1.0	1.0	1.0	1.0*	1.0
1.5	0.5	1.0	1.5	0.5*	0.5	1.5	1.0
1.0	1.5	1.0	0.5	1.5	1.0	1.5	0.5*

Experimental Results

Reaction Time. By reference to Table 1 it can be seen that the average reaction time for nonrhythmic presentation was 5.95 percent slower than for the rhythmic presentation of the stimuli. The t-ratio was computed from the distribution of differences obtained by subtracting each subject's mean score under rhythmic conditions from his nonrhythmic mean. It was 8.95, which was far above the critical figure of 2.68 required for significance at the 1 percent level. There was no significant difference in the standard deviations of the reaction times under the two conditions ($F = 1.02$, compared with 1.60 required for the 5 percent level).

Equated Intervals. It was discovered that the average time between the nonrhythmic series of flashes prior to the stimulus was .914 sec., whereas it was a full second for the rhythmic series. By eliminating the nine trials for each subject that had the shortest flash interval, the remaining 26 trials averaged one second as desired. The corresponding trials for the rhythmic condition were also eliminated in order to preserve the balanced design of the experiment. It is known that the length of the interval between a preparatory signal and a reaction stimulus influences the reaction time (12).

For the time-equated data (shown in Table 1), the average slowing caused by the nonrhythmic compared with the rhythmic presentations was somewhat smaller than before the equating. It was .0110 compared with .0118 sec., i.e., 5.54 compared with 5.95 percent. The t-ratio, namely 7.08, showed that the effect was still highly significant, and the variability difference remained nonsignificant ($F = 1.22$).

Movement Time. The net movement time (also shown in Table 1) was almost identical under the two conditions, the difference being approximately one-thousandth of a second ($t = 1.33$). The standard deviations were also equal within the limits of sampling error ($F = 1.05$).

Intercorrelations of Individual Differences. Using the average of the 35 scores for each individual under each condition, the correlation between the

TABLE 1. — REACTION AND MOVEMENT TIMES WITH TWO TYPES OF STIMULUS PRESENTATION

Measure	Rhythmic		Nonrhythmic		Differences			
	M	σ	M	σ	M	%	t	$F\sigma$
Reaction time (sec.) (*Original series*)	.1983	.0197	.2101	.0195	.0118	5.95	8.95	1.02
Reaction time (sec.) (*Equated intervals*)	*.1985*	*.0210*	*.2095*	*.0233*	*.0110*	*5.54*	*7.08*	*1.22*
Movement time (sec.)	.2077	.0282	.2092	.0288	.0015	0.72	1.33	1.05
Total time (sec.)	.4060	.0391	.4193	.0401	.0133	3.28	—	—

rhythmic and nonrhythmic reactions was found to be $r = .889$. Using the time-equated scores, it was .885. Since these coefficients included any attenuation caused by variability in the influence of stimulus rhythmicity, it is possible that the true reliability was somewhat higher than given by these figures.

The corresponding reliability correlation for movement time was very high, namely $r = .962$. It was observed that the nonrhythmic reaction and movement times were equal within sampling error ($t = 0.88$), as intended in the design of the experiment. The rhythmic reaction time was .009 sec. faster than the rhythmic movement time. This small difference was of borderline statistical significance ($t = 2.28$, compared with 2.01 required for the 5 percent level).

A low positive correlation, $r = .308$, was found between reaction and movement times. Compared with a correlation of zero, this would be considered of borderline statistical significance ($t_r = 2.17$). There was no significant correlation between the rhythmic reaction time scores and the rhythmic-nonrhythmic differences ($r = -.185$, $t_r = 1.30$).

Discussion

Miles (9) used the term "unison" to describe the absence of variability among individuals with respect to their quickness of response. It would seem advantageous under some conditions to have the football linesman move as a unit. While his data showed that unison was better under the rhythmic condition, he made no test of statistical significance. In the present study, unison was the same under both rhythmic and nonrhythmic conditions, within the limits of random differences. The F-ratio test of the difference in the standard deviations showed this to be the case. On the other hand, clear statistical evidence was observed that the reaction time was about 6 percent faster under the rhythmic conditions. This agrees with Miles, although the effect was much smaller than he found.

The faster speed of reaction under the rhythmic compared with nonrhythmic conditions may in part be attributed to differences in the foreperiod. In the experiment, the foreperiod is somewhat complicated. The interval between any two consecutive flashes of the small light constitutes a foreperiod because the stimulus may accompany any flash of the small light. Woodworth (12) reviews data that show that the quickness of a reaction depends on the adequacy of the preparation. If the foreperiod is too short, the subject will not have time to get ready, but if it is too long, his readiness may fade away. There is usually a tensing of the muscles which execute movement during the foreperiod; the higher the tension at the end of the foreperiod, the quicker the reaction. The tension is apt to be greatest when the foreperiod is regular and of the most favorable length (12). In a nonrhythmic series, many of the individual single foreperiods would necessarily be different from the optimal, whereas in the rhythmic series, all single foreperiods can be optimal.

Another and perhaps more important factor may be the rhythmicity as such. If it is known just when a possible stimulus can occur, the mental readiness of the subject (12) as well as his preresponse muscle tension can be periodically raised at these possible reaction points. This is not possible in the nonrhythmic series.

Thompson *et al.* have offered a different explanation. They attribute the faster reaction under the rhythmic condition to the greater possibility that the subject will use the motor set rather than the sensory set, as compared with the nonrhythmic condition (11). They state that it is a generally accepted physiological fact that concentration on the starting signal produces a slower reaction time than concentration on the motor response to that stimulus. Two recent experiments, however, have cast serious doubt on the concept that the motor set gives the faster reaction. In fact, most subjects seem to react faster when they concentrate on the stimulus rather than the movement (6).

The factual findings of the present study do, however, agree in principle with those reported by Thompson *et al.*, as well as with the earlier work of Miles. Those results have been extended to establish that under carefully controlled conditions, with the reaction of the experimenter excluded, the preparatory signal intervals equated, the influence of learning balanced out, and reaction and movement times separated, the rhythmic method does result in faster reaction times than the nonrhythmic. Speed of movement, however, is not found to be significantly influenced by rhythmic presentation of the stimulus.

The amount of change in reaction time, while highly significant statistically, is found to be much smaller in the present investigation. This difference in factual results is without question statistically significant. In the Thompson studies, the difference due to the rhythmic method was .05 sec. with a standard error of .0057, while in the present experiment it is .0118 sec. with a standard error of .00132. The t-ratio for the difference between the two experiments, therefore, is 6.54, compared with the figure of 2.64 that is required for the 1 percent level of significance. While this smaller difference in advantage may be the result of using different subjects, it seems more likely that it is caused by the stricter control conditions of the present investigation and, possibly, by the avoidance of very short nonrhythmic intervals.

In the field of physical education and athletics, much of the controversy over the role of reaction time has come out of mistakes in terminology. What the coach and physical educator are calling reaction time is actually a variable combination of reaction and movement times. At times this combination has been called general "quickness." Keller (7), for example, has shown that there is a significant relation between the ability to move the body fast (quickness) and success in athletic activities.

Biese and Peaseley (1) had reported such a relation earlier, but a careful examination of their results reveals that in arm reaction time their skilled group ranged from .16 to .34 sec. compared to a range of .17 to .42 sec. in

their unskilled group. For leg reactions, the skilled group ranged from .41 to .62 sec. compared with .45 to .85 sec. in the unskilled group. Thus the skilled and unskilled groups were strikingly similar rather than different in their reaction time abilities, although they were clearly differentiated and did not overlap at all in speed of running and scores in the agility run tests. At about the same time, Rarick (10) had reported that the correlation between leg reaction time and sprint speed was only .16 on one day and .11 on another, neither of these differing significantly from zero.

More recently, it has been observed under controlled laboratory conditions that reaction time and speed of arm movement, both measured during the same response to a stimulus by using two chronoscopes, are independent and uncorrelated to any practically important amount (4). This has been confirmed in the present study. Because of this fact, it becomes very important to measure separately and distinguish between reaction time to a stimulus (which is the time between the stimulus and the *start* of movement) and the speed of the movement which is initiated by the reaction. While factors influencing speed of reaction have been studied using the response made in an athletic situation (2, 5, 7, 8, 11, for example), the role of quickness of reaction in individual athletic proficiency has been assumed; it has not been clearly established either by experimentation or controlled observation.

Summary and Conclusions

The reaction time and movement time of 50 college men was measured with both rhythmic and nonrhythmic stimulus presentation. This was accomplished by establishing a preparatory signal cadence of eight light flashes in each test. The stimulus to react was the flash of a larger distinctive light which accompanied one of the cadence flashes, its position being randomly located among the last five cadence flashes. There were 35 reaction trials under each of the two conditions. A balanced experimental design was employed to control practice, fatigue, and other variables. The movement consisted of a vigorous upward and forward movement of the arm, involving a distance that yielded equal times for the net reaction and net movement phases of the total response to the signal, under nonrhythmic conditions.

The average reaction time was .198 sec. with the rhythmic signal presentation. It increased significantly to the extent of 5.95 percent when nonrhythmic presentation was used. The average movement time, .208 sec., was not significantly influenced by the method of signal presentation. The correlation between individual differences in reaction and movement times was quite low ($r = .308$) and of questionable significance. There was no significant difference in individual variability of response under the rhythmic and nonrhythmic conditions.

The faster reaction under the rhythmic condition was explained by the postulated tendency of the subject to come periodically to a maximum degree of readiness at each time there was a stimulus possibility. An additional factor

was the probability that not all foreperiods would be optimal with non-rhythmic presentation.

The conclusions, which of course apply only to the range of conditions covered in the experiment, are:

1. Reaction time is faster when potential stimuli are presented in a rhythmic rather than nonrhythmic series.

2. The speed of the movement initiated by such reaction is not influenced by the rhythmicity or non-rhythmicity.

3. Individual differences in quickness of reaction and quickness of movement are almost completely independent.

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(Submitted 7/23/58)

Factors Influencing Diurnal Variation of Strength of Grip[1]

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Abstract

An investigation of strength of grip through the day has disclosed a diurnal pattern which is not modified by repeated testing, starting tests at different times, or by staying awake all night. Experiments suggest that immobilization is unlikely to be the cause. The parallelism of grip strength and temperature was noted, and experiments in which the body temperature was artificially changed suggest that the relationship between the two is close.

STRENGTH OF GRIP has been commonly used as a measure of muscle power (2, 4, 6, 7, 9, 10). An investigation of variations in strength of grip throughout the day has disclosed a diurnal pattern. This is of fundamental importance in the interpretation of reports of strength of grip and as a physiological phenomenon. A study has therefore been made of this diurnal variation and factors which may influence it.

Procedure and Methods

Four types of instrument were used. One was a modification of the Geckeler pneumatic dynamometer (5). An inflatable rubber bag encased in soft leather was blown up to a pressure of 20 mm. of mercury by a sphygmomanometer bulb and attached to a mercury manometer. This was particularly useful in the measurement of weak grips. Other instruments used were the Collin elliptical spring steel dynamometer, the Smedley dynamometer (6), and a modification of the tensiometer (3). Grip strength was measured at intervals through the day by an independent observer. Three grips were measured with each hand and the average taken. The subject was not allowed to see the readings or to know any results until the end of the day, to minimize psychological factors.

General Review of Results

In the first 18 subjects readings were taken every 15 minutes from 6:00 a.m. to 9:00 a.m. and then hourly until 10:00 p.m. It was found, however,

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[1] I am indebted to Dr. A. G. S. Hill, with whom this study was started, and to Professor S. J. Hartfall, with whose encouragement and interest it has continued. My thanks are also due to R. E. Morgan and G. T. Adamson of the Physical Education Department for their helpful discussions and the loan of apparatus.

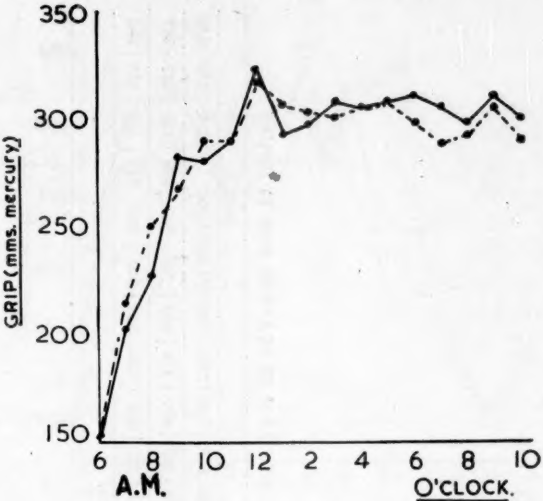

FIGURE I. Diurnal variation of grip strength measured from 6 a.m. to 10 p.m. —— right hand, ... left hand.

that the shape of the curve of variation was not altered in these subjects by taking hourly readings through the whole day, so this practice was adopted in later experiments. There was close correlation between the readings of all instruments in individual subjects.

Seventy-five tests in 35 subjects showed a diurnal variation similar in pattern to Figure I. On 23 occasions the test was continued through the night, waking the subject at two-hour intervals, and the pattern in Figure II was found. There was a marked increase in strength of grip from 6:00 a.m. to 9:00 or 10:00 a.m., sometimes a more gradual increase from then to 12:00 noon or 1:00 p.m., and a great decrease at night. In three subjects there was no marked increase in the morning, but the decrease at night was a constant feature in all.

This phenomenon was not abolished or modified by repeated testing. Twenty-five tests were done on one subject over two years, and the same pattern was preserved. A subject tested continuously for three days showed no change of pattern.

Three subjects began readings at 6:00 p.m., to find the effect of starting the study at a different time. The same diurnal pattern was revealed (Figure III). Staying awake at night did not alter the marked fall in grip strength at night in seven subjects.

Effect of Immobilization

It was possible that immobilization might be the factor which was responsible for this phenomenon. The left arm of a subject was therefore immo-

TABLE 1.—EFFECT ON GRIP STRENGTH OF IMMOBILIZING LEFT ARM IN PLASTER FOR 24 HOURS

		A.M.						P.M.												A.M.		
Time		7.20	8.00	9.00	10.00	11.00	12 noon	2.00	2.30	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.40	11.40		2.40	4.00	6.00
Grip Strength mms. mercury	Rt.	510	520	513	510	540	520	510	570	577	563	540	567	617	578	630	547	553	450	440	387	397
	Lt.	ARM IN PLASTER						403	520	543	517	515	507	557	540	543	540	523	417	367	353	363

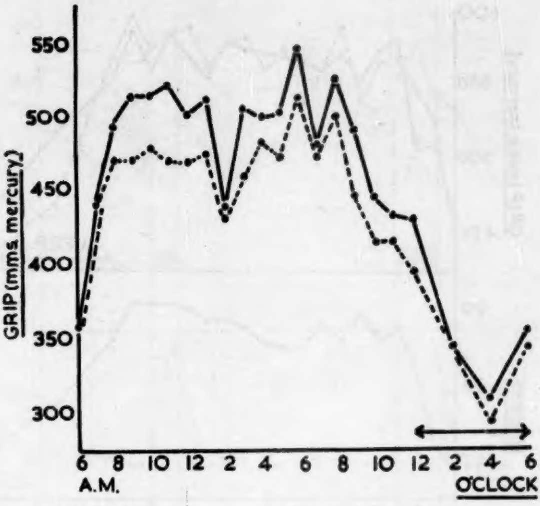

Figure II. Diurnal variation of grip strength in a subject over 24 hours. — right hand, — left hand.

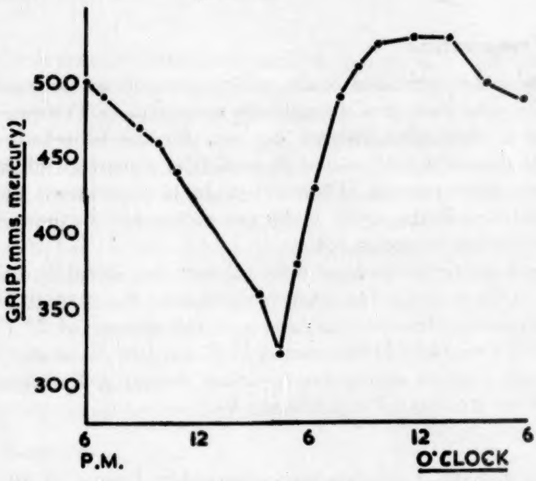

Figure III. Diurnal variation of grip strength in a subject beginning readings at 6 p.m. (both hands virtually the same grip).

bilized in plaster for periods of 8, 13, and 24 hours. The results of the last experiment are shown in Table 1. On each occasion the strength of grip returned to its normal value in ½–1 hour. It is unlikely, therefore, that immobilization is the sole causative factor, if it is responsible at all.

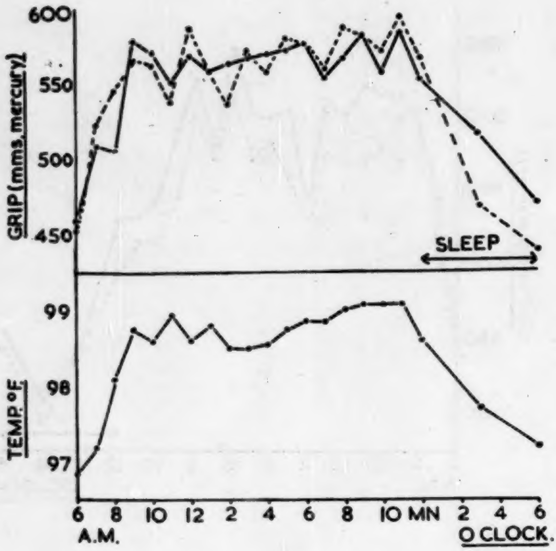

FIGURE IV. Diurnal variation of grip strength and temperature. —— right hand, ... left hand.

Relation to Body Temperature

The body temperature was estimated orally, taking precautions to avoid sources of error, at the same time grip strength was measured, in 23 experiments. There seemed a correlation between the two, for the temperature showed a considerable diurnal variation and in particular a marked fall at night parallel with grip measurements (Figure IV). In 15 experiments not only was there a correlation in the trend of the two curves but maxima of grip strength and temperature corresponded.

In another experiment the temperature of three subjects was raised by immersion in hot water at times of the day when it was known the strength of grip was static or decreasing. In each case a rise of temperature of 2° F. increased the strength of grip, but a further rise of 1° F. (to 101° F. or over) did not increase the grip strength and on two occasions decreased it. Subsequent cooling reduced the strength of grip (Figure V).

Discussion

Diurnal variation in strength of grip has been observed by Rogers (9, 10) and Clark (2), but they did not report further investigations of the phenomenon. It is of importance in the compiling and interpretation of data in normal subjects. Thus Jones in his excellent study of motor performance and growth (7) accounts for monthly periodicity and seasonal variation but makes no mention of diurnal variation. In certain chronic diseases, such as

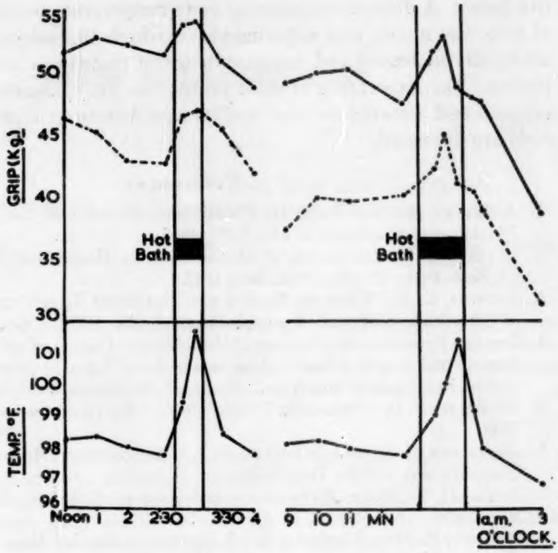

FIGURE V. Effect of raising the temperature and subsequently lowering it on a subject's strength of grip. —— right hand, ___ left hand.

rheumatoid arthritis, grip strength is used as a measure of progress and the effectiveness of therapy in trials of new drugs. It is advisable therefore to measure grip strength at the same time of day for each assessment.

The results of this study suggest that the diurnal variation of grip is a manifestation of a fundamental body rhythm and is paralleled to some extent by variation of temperature. Parallel variation is not adequate evidence, however, for regarding two things as cause and effect, since other substances in the body which show a diurnal variation of similar pattern are almost certainly not directly related, e.g., plasma iron and adrenal secretion (11). Nevertheless, the results of heating experiments suggest that the relation may be a close one and lend support to the view that warming-up in athletes increases muscle power, as suggested by Neilsen (8) and Asmussen and Bøje (1). It is of interest that raising the temperature beyond physiological limits produced no further increase in grip strength.

Summary

In 75 tests on 35 subjects a diurnal variation in strength of grip was observed; 23 tests showed that there was a profound fall in grip strength during the night, which usually returned by 9:00 a.m. Repeated testing, beginning tests at different times, and staying awake at night did not alter the pattern. The rapid recovery of strength following immobilization of the arm in plaster for varying lengths of time suggests that immobilization is not the sole causa-

tive factor. A diurnal variation of body temperature parallel with the strength of grip was noted, and experiments in which the subject's temperature was artificially increased and decreased suggest that the relation between the two is close. The importance of these findings in the evaluation of data in normal subjects and diseased patients and its significance as a physiological phenomenon are discussed.

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(Submitted 2/28/58)

Notes and Comments

NOTE

Precision and Operation of the Hundredth-Second Electric Timer

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JUDGING by illustrations that have appeared in several recent articles in the *Research Quarterly*, the "Standard" electric timer[1] or chronoscope has come into widespread use. There is need, therefore, to examine the dependability and precision of this instrument and to consider some of the technical problems that occur in its use.

Functional Principles

The instrument is well-designed and rugged; it operates on a simple principle. A synchronous A.C. motor drives a notched control disc through a friction clutch. The control disc is connected to a sweep second pointer that rotates over a dial divided into hundredths of a second. Each division is one-tenth of an inch wide. There is also a smaller pointer that reads cumulated seconds. These pointers are also driven by friction and carry heart-shaped cams so that pressure on a reset lever will return both of them to zero.

A pair of pivoted armature levers carry knife-edge pawls that normally press into the notches of the control disc, so that when the motor is switched on the disc does not turn. Operating a control switch energizes the armature coil and forces the pawls to lift, thus causing the control disc to turn the pointers. When the armature switch is opened, the pawls re-engage the control disc and stop it. The armature is usually operated by the same A.C. supply that drives the motor but is supplied with a separate control switch.

Accuracy

The accuracy of measurement with this timer is, of course, ultimately determined by the alternating current supply system. The writer has been advised by power company engineers as well as by other authorities that this error is considerably less than 0.001 sec. and can be neglected in the case of large interconnected power systems such as those in California.

A second limiting factor is the number of notches in the control disc. A direct count puts this number at 370. This agrees fairly well with tests of possible pointer positions, which seem to be 15 within each series of four dial divisions, totaling 375 notches. Since each notch represents 2.7 thousandths of a second, (i.e., 2.7 $sec.^{-3}$), the limiting mechanical accuracy of a *single* reading is 1.35 $sec.^{-3}$ (In a *series* of measurements it could be considerably less, because the mechanical action would function to divide the data into class intervals.)

A third limiting factor is the error in reading the dial. If the pointer reading is interpolated to tenth divisions, using care to avoid parallax error, an experienced operator can usually keep within 1.0 $sec.^{-3}$

[1] Model S-1 Precision Electric Timer, manufactured by the Standard Electric Time Company, Springfield 2, Mass. (approximate cost, $100).

Preliminary Results

In another study (1), the writer reports the variable error of three of these instruments as 6.66 sec.$^{-3}$ with no significant differences among the three. These particular chronographs had each been used to measure more than 100,000 reactions over a period of some nine years and had received no attention beyond an occasional drop of light oil on the friction clutch and end bearings as recommended by the manufacturer. The constant error was not measured. Subsequently, two other instruments with a service record of some 20,000 reactions each (without oiling) have been tested in greater detail.

Testing Apparatus

An ancient RCA electric record player has been modified to produce a constant time interval.[2] The turn table of this device is directly connected with the rotor, which is quite large, so that it functions as an extremely accurate manually started synchronous motor turning 78 rpm or 769.23 sec.$^{-3}$/rev. The stator assembly has been immobilized and a heavy cam has been mounted on the turntable shaft, dimensioned so that it closes a microswitch contact for 200.0 sec.$^{-3}$ The duration is determined by marking the "on" and "off" positions of the contact on the rim of the turntable, using a light and battery in series with the contacts. Since the rim has a circumference of 22.00 in., the "on" phase requires 5.720±0.005 in. (the required accuracy here being 0.1%, it is necessary to average at least 10 measurements). A small lever on the microswitch mount can be turned to spring the switch arm upward to miss the cam, permitting the experimenter to connect or disconnect the contact during the "silent" phase of the turntable revolution.

Arrangements for energizing the armature magnets of the two chronoscopes by direct current have been accomplished with the right hand circuit shown in Figure I. It may be noted that this circuit is designed for practical use in reaction and movement timing, in cases where the highest possible precision is desired. The components are mounted in the open air, on the back of one of the chronoscope cases.

Experimental Results

Data obtained from 120 tests for the pair of chronoscopes under each specified condition are summarized in Table 1. It will be noted that one of the conditions includes a battery-operated relay. This is a special quick action nonchattering type designed for aircraft electronic circuits. The point separation is only 0.004 in. Other types of relays

TABLE 1.—CONSTANT AND VARIABLE ERRORS OF TWO CHRONOSCOPES

Armature Current	Error Source	Instrument A		Instrument B		Average		
		M[a]	σ^2	M[a]	σ^2	M[a]	σ^2	σ_e
D.C.	Instrument	0.74	0.722	0.20	0.626	0.47	0.674	0.82
	Cam	0.08	0.371	0.08	0.371	0.08	0.371	0.61
	Total	0.82	1.093	0.28	0.997	0.55	1.045	1.02
D.C. with relay	Instrument	0.74	0.917	0.20	0.798	0.47	0.858	0.93
	Relay	1.60	0.814	1.31	0.814	1.46	0.814	0.90
	Cam	0.08	0.371	0.08	0.371	0.08	0.371	0.61
	Total	2.42	2.102	1.59	1.983	2.01	2.043	1.43
A.C.	Instrument	----	1.623	----	1.271	----	1.447	1.20
	A.C. error	−4.12	1.076	−5.99	1.076	−5.06	1.076	1.04
	Cam	0.08	0.371	0.08	0.371	0.08	0.371	0.61
	Total	−3.30	3.070	−5.71	2.718	−4.51	2.894	1.70

[a] The reference value for these means is 200.0. All units are sec.$^{-3}$ (i.e., 0.001 sec.).

[2]Some of the modern record players would not be sufficiently constant in speed to be useful for error determination.

not suitable for this use have given variable errors as large as 18. sec.$^{-3}$ and constant errors as large as —21. sec.$^{-3}$ It may be noted that the constant error of the cam has been determined by averaging ten measurements of the turntable as explained above.

Attention may first be directed to the constant errors shown in Table 1. The instruments evidently indicate the time very accurately with the D.C. circuit, using the computations from the cam measurements as a reference standard. Use of the relay increases the error considerably, although it is still only 2 sec.$^{-3}$ When the armature is energized with A.C., the indicated time is too small to the extent of 4 to 6 sec.$^{-3}$ (Note that this is a *difference* and thus is not influenced by the cam accuracy.)

In most applications, the variable error is of more concern than the constant error. The average net instrument error variance has been determined for each test situation, by using $\frac{1}{2}\sigma^2_{A-B}$ computed from the differences in the readings of the two chronoscopes at each trial. Subtracting this from the average of the total error variance gives the error variance of the calibrating cam. This value, subtracted from the total variance for each instrument, gives the net instrument error variance for each. A similar series of operations on the data obtained with the relay yields the error variance of the cam plus the relay. The former was already determined, and when it is subtracted, the remainder is the net error variance of the relay.

With A.C. armature operation, the first step is to determine the average net instrumental error variance, which is $\frac{1}{2}\sigma^2_{A-B}$ as before. This is subtracted from the average total error variance, to yield the sum of the cam error and A.C. error variances. Since both the cam and A.C. variances may be assumed to be the same for both instruments, they may be subtracted from the total variance for each separate chronograph, the remainder being the net error variance for each instrument. The net error variances from the several sources are necessarily uncorrelated.

These results are most meaningful in the form of the errors, rather than variances. The right hand column of Table 1 lists the errors for the several sources and conditions. It is noteworthy that the net instrumental error is less than a thousandth of a second when the chronoscope armatures are operated with D.C. The variable error of the relay is about as large as the chronoscope error, and the variable error of the cam, while smaller, is considerable. However, the *total* variable error is less than ± 2 sec.$^{-3}$ even with A.C. operation of the armature.

Adjustment and Care of Friction Clutch

The three instruments examined in the preliminary testing were partially disassembled and the main friction drive clutches and springs cleaned with carbon tetrachloride. In re-assembly, the shaft was lightly oiled but care was taken that *no oil was on the friction groove or spring.* Squeaking of the friction springs was eliminated by a minimal amount of dry graphite lubrication, using a soft pencil shaped to the groove and applied lightly while the motors were running. Before this reconditioning, the average error variance ($\frac{1}{2}\sigma^2_{A-B}$) for the three on A.C. was 4.36 sec.$^{-3}$; afterward, it was only 1.53 sec.$^{-3}$

A sixth instrument, which had been heavily used and occasionally oiled, had been shelved for repairs when it was discovered to have a constant error of about 15 sec.$^{-3}$ compared with other chronoscopes. It was found to have a total variable error variance of 8.16 sec.$^{-3}$ on A.C. After the above treatment, the constant error was —4.12 and the total variance 1.91 sec.$^{-3}$ when tested on the calibration cam. A seventh instrument, new and unused, was found under test to have a constant error of —8.26 sec.$^{-3}$ with a variance of 8.77 on A.C., and 2.94 constant error with a variance of 2.39 on D.C. The friction clutch was not oily, but it was made of white plastic rather than metal as in the others. The clutch was removed and the spring fork bent so that the separation of the prongs was reduced to about ⅛ in. With this increase in friction on the clutch, the accuracy using A.C. was —4.17 sec.$^{-3}$ constant error with a variance of 1.77; using D.C. on the clutch armature, there was 0.96 constant error and 0.87 variance.

One may conclude from these observations that the manufacturer's instructions to oil the clutch represent poor advice. The clutch groove and spring should be kept free of grease and should receive a minimum of dry graphite if it be required. Moreover, the possibility of a weak friction spring must be considered, even with a new instrument.

Control Circuits

With the clutch running dry, it is important that the motor is not run needlessly. It must of course be in motion before the clutch is energized or considerable error will result. This can easily be accomplished with normal A.C. operation by connecting the single wire motor lead (#3) across the warning or preliminary signal circuit, as in the left hand diagram of Figure I. The warning switch (S_1) must be opened promptly when the subject's movement has been completed. Relays in the armature control or "keying" circuit (between leads #2 and #3) should be avoided if possible. It has

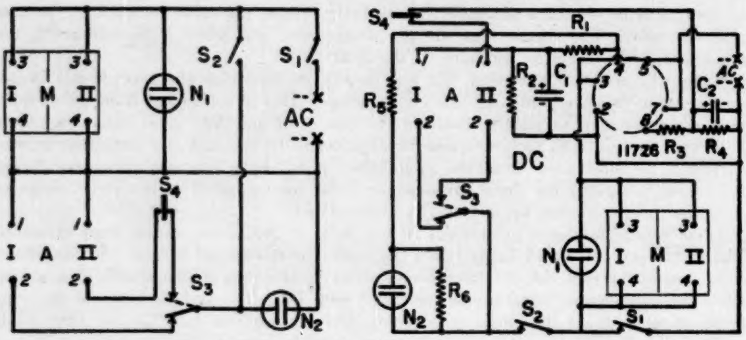

FIGURE I. Chronoscope Circuits for Measuring Reaction and Movement Times.

The left-hand circuit measures reaction and movement times with A.C. operation of the drive clutches. The right hand circuit gives greater precision by using a 117Z6 rectifier tube to furnish D.C. for the clutch armatures (A) and stimulus light (N_2).

Resistors R_1 and R_2 are 1,000 ohm 10 watt; R_3 and R_4 are 6,000 ohm 10 watt; R_5 is 10,000 ohms and R_6 is 1 megohm (both are ½ watt). Capacitors C_1 and C_2 are 10 mfd. electrolytic 450 W.V. common negative, with the cam insulated or taped for safety. Chronoscopes I and II have their clutch armature leads #1 (unmarked) disconnected from #4 (they had been connected at the factory) and reconnected to points #1 in the diagram. The other three leads (marked #2, #3 and #4 at the factory) go to the labeled points in the diagram. The A.C. line voltage is to be attached at points X X.

Closing S_1 (either circuit) starts the motors (M) and lights the warning bulb N_1 (GE-NE 45). Pressing the reaction key S_2 lights the reaction signal N_2 (GE-NE 51 for D.C.; NE 45 for A.C.). It also starts Chronograph I. S_2 is a fast action silent lever switch that must remain closed while the subject reacts and moves. By bending one inner springleaf to make contact on the middle position, a three position double circuit switch can serve for both S_1 and S_2. (Model 3037L, Switchcraft Inc., Chicago 22, Ill., is suitable.)

The subject has been holding the microswitch S_3 pressed down; when he releases pressure it springs up to stop Chronograph I and start Chronograph II. He moves, striking a target that pulls a small metal strip out of S_4 to stop Chronograph II. It is also possible to use a trigger-release microswitch at S_4.

been the writer's experience that contact imperfections are difficult to avoid and may give rise to very large errors. Microswitches, rather than ordinary keys, should be used whenever possible.[3]

Stimulus Circuits

The use of an incandescent light or flashlight bulb as the stimulus will introduce a large error, which will change as the filament warms up. Such lights do not illuminate instantly. A neon glow lamp is much to be preferred. The GE-NE 45 is suitable. Care must be taken that both halves of the split plate are equally visible to the subject. Used on A.C., one of the two plates lights at each half cycle of the 60 cycle supply; i.e., there are 120 flashes per second. These flashes are separated by a dark period of about 2.3 $sec.^{-3}$ This error is not serious if one is satisfied with a total accuracy of a hundredth second, but for more precise work the neon bulb must be lighted by direct current. (Note that this illuminates only one of the plates.)

A D.C. stimulus circuit is included in the right hand diagram of Figure I. The stimulus light N_2 must here be the GE-NE 51; the warning light N_1 is the GE-NE 45 as before. The series resistor R_5 is 10,000 ohms, since the D.C. voltage is only 60. (A larger resistor such as is normally used will only illuminate the light on the A.C. ripple, resulting in momentary dark periods between cycles.) The purpose of the shunt resistor R_6 is to extinguish the light if feedback in the wiring causes it to glow when it is supposed to be off. Its value should be 1 megohm, although it could be as low as 100,000 ohms if necessary.

Required Accuracy of Dial Reading

The large pointers of the two chronographs used for the data of Table 1 were bent closer to the dial, in order to reduce parallax error. A series of 100 reactions, varying from 84 to 480 $sec.^{-3}$, was then measured with the instruments in parallel, using the D.C. circuit of Figure I and interpolating the pointer position to tenth divisions. The instrument error ($\sqrt{\frac{1}{2}\sigma^2_{A-B}}$) for these data is 1.05 $sec.^{-3}$ When the original data are rounded off to the nearest half division, and the error again calculated, it is found to be 3.00 $sec.^{-3}$ When the data are rounded off to the nearest whole division (a hundredth second), the error is 6.38 $sec.^{-3}$ These results are so clear that they require no comment.

Conclusions

The hundredth second electric precision timer used with the usual A.C. clutch circuit has an accuracy within ±0.5 hundredths of a second as determined experimentally, provided that the drive clutch is kept free of oil, the readings are made to the nearest half-hundredth, and switches or relays are of known dependability. The clutch spring may need tightening on some instruments. Neon bulbs rather than filament type lamps are required for the stimulus signal. A variable error of ±2 thousandths is possible if the clutch is in good condition and the dial readings are interpolated to tenth divisions, but there is a constant error of —5 thousandths with A.C. operation. Use of a D.C. clutch and stimulus circuit, which is described, reduces both constant and variable errors to nearly one thousandth of a second, although a single reading cannot have an accuracy closer than ±1.35 thousandths.

Reference

1. Henry, F. M. "Reliability, Measurement Error, and Intra-Individual Differences." *Research Quarterly* **30**: 21-24; Mar. 1959.

[3] Type RW 80 or BZ-2RW82, manufactured by the Micro Switch Division, Minneapolis-Honeywell Regulator Co., Freeport, Ill.

(Submitted 8/7/58)

Research Abstracts

Prepared by the Research Abstracts Committee of the National Council of the Research Section, D. B. VAN DALEN, Chairman

1. ADAMS, THOMAS, and HEBERLING, E. J. "Human Physiological Responses to a Standardized Cold Stress as Modified by Physical Fitness." *Journal of Applied Physiology* **13**: 226-30; Sept. 1958.

Five nude subjects were exposed for one hour to ambient temperatures of 50° F (10° C) before and after a training program which significantly increased levels of physical fitness. A comparison of body responses showed that heat production averaged 15 Cal/hr/m^2 higher, that the mean rectal temperature dropped 0.5° C, that the average skin temperature rose 1.0° C, and foot and toe temperatures increased 3.0 and 4.0° C respectively after the training period. No significant change in average body temperature was found. These results indicate that many accepted indices of cold acclimatization may be produced by raising the physical fitness level.—*Peter V. Karpovich* and *Lora M. Ewing.*

2. ALPERT, N. R., *et al.* "Relationship among Recovery Oxygen, Oxygen Missed and Lactate Removal during and Following Severe Hypoxia in the Unanesthetized Dog." *American Journal of Physiology* **192**: 585; March 1958.

An experiment was set up to test the "O_2 debt" hypothesis. Oxygen intake and plasma lactates resting and recovery, following hypoxia, were measured. The larger the depression in O_2 during hypoxia the greater was the depression during recovery and the longer to return to normal. No correlation existed between lactate removal and recovery O_2 consumption. Instead of going into debt for O_2 the animal pays as he goes.—*Ernest D. Michael.*

3. ARNOV, BERNARD M. "The Influence of Consistent and Inconsistent Guidance on Human Learning and Transfer." *Journal of Educational Psychology* **49**: 2; April 1958.

Eighty-eight college students, male and female, under 26 years old, and essentially inexperienced with maze problems served as subjects. They were randomly assigned to Group I, II, or III. The subjects were given consistent, inconsistent, or no guidance concerning various mazes which they would encounter. The purpose of the study was to answer the question: In what ways did the guidance affect their learning behavior, both in the immediate and in a transfer situation? Consistent guidance was not markedly different from that of no guidance. Inconsistent guidance usually had a detrimental influence on learning; however it did not necessarily have lasting damaging influence. Lasting damage resulted from inconsistent guidance when the recipient of the guidance for some reason was unable to rebel and ignore the guidance.—*D. B. Van Dalen.*

4. BAKER, PAUL T., and SCHRAER, HAROLD. "The Estimation of Dry Skeletal Weight by Photometry of Roentgenograms." *Human Biology* **30**: 3; Sept. 1958.

Experiments with 11 femora indicated that a simple trace path across the midshaft was adequate to predict total femur weight. Material from Korean War dead showed accurate predication could be made for white skeletal weight, and with limited accuracy for Negroes. With the use of x-ray mass coefficients, the total dry skeletal weight can be predicted with a standard error equal to approximately one-half the standard deviation of dry skeletal weight. These results were obtained on skeletal material and cannot be

applied to living without further modification of the technique or derivation of a soft parts correction. With the completion of this correction, the dry skeletal weight should offer a valuable adjunct to our methods of measuring normal body composition.—*D. B. Van Dalen.*

5. BALKE, B., and WELLS, J. G. "Ceiling Altitude Tolerance Following Physical Training and Acclimatization." *Journal of Aviation Medicine* **29**: 41-47; Jan. 1958.

The altitude tolerance of six subjects was tested in a low pressure chamber before and after a physical conditioning program and after acclimatization to an altitude of 14,000 feet. The physical training resulted in an improvement in altitude tolerance of approximately 3,000 feet. Regular physical activity during the period of altitude acclimatization provided for a faster and more effective adaptation.—*Wayne D. Van Huss.*

6. BARNICOT, N. A. "Reflectometry of the Skin in Southern Nigerians and in Some Mulattoes." *Human Biology* **30**: 2; May 1958.

One hundred Yoruba males and 94 Yoruba females, 50 male Ibo students and 14 male Yoruba students were measured. The European sample was made in London one year later and comprised mainly the academic staff, students, and technicians at the University College. The Evans Electroselenium Company reflectometer was employed. The reflectance was found to be lower in male subjects both African and European. The Yoruba of Southwestern Nigeria are shown to be somewhat darker than the Ibo from the Southeast. Some reflectance data on offspring of crosses between Europeans and Africans are presented as a contribution to the genetics of skin color differences.—*D. B. Van Dalen.*

7. BELBIN, EUNICE. "Methods of Training Older Workers." *Ergonomics* **1**: 207-21; May 1958.

Three experiments showed that subjects in middle age learn more quickly and thoroughly if they perform the tasks rather than memorize instructions. The first experiment used 44 subjects, ranging in ages from 20 to 70. The subjects were divided into four age groups, each having an equal number of men and women. Each subject performed a card sorting task twice. Half of the subjects performed by the activity method first and the memorizing method second. The other half performed the tasks in opposite order. The results showed that the 20-29 age group was significantly faster by the memorizing method than the other age groups. The twenties group was not significantly faster in learning time by the "activity" method than the thirties and forties, but was significantly faster than the fifties group. Accuracy in performance was greater after the activity method by all age groups.

The second experiment used two groups of subjects, eight between 18 and 22, and eight between 30 and 49. Each group performed card posting tasks by both the memorizing method and the activity method. The younger subjects reached target time more quickly after learning by memorizing; the older subjects by the activity method. Differences both in learning time and posting time existed between the groups after the memorizing method. A difference only in learning time existed after the activity method. Both younger and older subjects were slightly more accurate after the activity method.

The third experiment involved training in mending worsted cloth. (Industries would not hire older workers for mending since it was claimed that older people could not learn invisible mending.) Twelve housewives between the ages 30 and 50 were divided into two groups of six each. One group was trained by the traditional exposure or sit-by-me method. The other group was trained by having practice on specifically woven large scale weaves. They were then told to copy them on a small frame using thick elastic rather than thread. The experimental group took less time to learn the weaves than when taught by the exposure method.

These experiments suggest that older people, if taught by an appropriate method, can learn tasks more rapidly and easily than they would otherwise. The activity method resulted in older subjects learning industrial tasks reasonably well and their performance compared favorably with the performance of younger trainees.—*Frances Z. Cumbee.*

8. Blank, Lane B. "Critical Requirements for Teaching Secondary School Physical Education." *California Journal of Educational Research* **9**: 1; Jan. 1958.

Forty-nine educators and 1619 junior and senior high school pupils participated as observers in this study. The critical incident technique was used. The principal conclusions were: effective physical education should provide capable instruction in activities and maintain good control of pupils; good teaching in physical education is most frequently characterized by effective instruction in skills and efficient program administration.—*D. B. Van Dalen.*

9. Cooper, R. M., and Zubeck, J. P. "Effects of Enriched and Restricted Early Environments on the Learning Ability of Bright and Dull Rats." *Canadian Journal of Psychology* **12**: 159; 1958.

Differential effects of enriched and restricted early environments were studied on 43 rats of the McGill bright and dull strains. Results showed no improvement in learning ability of bright rats reared in enriched environment over bright controls reared under normal conditions. Dull animals benefited from the enriched experience and reached a level of performance equal to that of bright animals. In a restricted environment dull animals showed no impairment as compared with dull controls, while bright rats were retarded to the level of the dull ones in learning. Performance was measured by the Hebb-Williams maze.—*C. Etta Walters.*

10. Devas, M. B. "Stress Fractures of the Tibia in Athletes or 'Skin Shoreness.'" *Journal of Bone and Joint Surgery* **40 B**: 227-39; May 1958.

Clinical evidence is presented on 16 cases of "skin splints" which indicates a type of stress fracture of the tibia is the cause. Progressive radiographs show the fracture to be difficult to diagnose because it is an incomplete fracture involving only one cortex of the bone and is not apparent in the radiographs until a later stage. It is mentioned that the radiological appearances of a low-grade inflamatory process associated with strains of muscles and that of stress fractures do not differ greatly. The radiographs, however, do not show the fracture until nearly three months after the onset of the symptoms.—*Wayne D. Van Huss.*

11. Distefano, M. K. Jr., Ellis, N. R. and Sloan, W. "Motor Proficiency in Mental Defectives." *Perceptual and Motor Skills* **8**: 231; 1958.

Seventy-six mentally defective subjects were tested on the Revised Stanford-Binet intelligence scale and on several motor tests. No significant differences were found between Caucasian and Negro subjects. Males were more proficient than females but only significantly so in rail-walking performance. The Lincoln-Oserestsky and Minnesota placing and turning tests were most highly related to mental age. Mental age and chronological age were not correlated, and chronological age and motor scores showed no significant relationship.—*C. Etta Walters.*

12. Eichorn, Dorothy H., and McKee, John P. "Physiological Instability during Adolescence." *Child Development* **29**: 2; June 1958.

Physiological instability during adolescence was examined by studying longitudinal data from the Adolescent Growth Study. Fifty boys and 50 girls constituted the sample group. Physiological measures of each subject were taken at six-month intervals between the ages of 11.5 and 17.5 years. The physiological indices used were: BMR, body tempera-

ture, systolic and diastolic blood pressure, and pulse rate. The author stated that for systolic and diastolic blood pressure and for pulse rate intra-individual variability increases throughout the period from 12 to 17, while variability in BMR decreases. Variability in body temperature shows little systematic change. Aside from these slopes, no period of variability was found for girls, and only a slight indication for boys.—*D. B. Van Dalen.*

13. Ford, E. H. R. "Growth in Height of Ten Siblings." *Human Biology* **30**: 2; May 1958.

Variations of growth in height were studied in an upper middle class English family of 10 siblings. There were 5 boys and 5 girls, all born between 1864 and 1884. Several conclusions were drawn from the study. The specific growth rate during the adolescent spurt of growth was the same for both sexes. Greater increase in males at this time was due to greater absolute size. Two thirds of the greater size in males was due to a longer period of growth; the remaining third was due to absolute size before adolescence and to a greater size increase at adolescence. There was no relationship between height and time of onset of the adolescent spurt. The rate of growth during adolescence was similar for all members of the family. Adult size was closely related to size at the beginning and at the peak of the adolescent spurt of growth. No clear evidence was found for the existence of a juvenile growth spurt.—*D. B. Van Dalen.*

14. Gelfan, S. "Muscle." *Animal Review of Physiology* **20**: 67-96; 1958.

This is a review and analysis of the more recent literature relative to muscle physiology. In reading it, one is impressed with how little is known with certainty regarding the action of muscle. Some of the more interesting concepts presented concerning skeletal muscles and their action were as follows:

(1) The muscle fibers composing one motor unit do not necessarily reside in a single fasciculus. (2) Muscle fibers frequently are innervated by more than one nerve fiber. (3) Actin and Myosin, or an actomyosin-like complex, form the basis for nearly all contractile movements throughout the animal world. The method of interaction between these two in the skeletal muscle is not yet clear. The two principal theories are: (a) an actomyosin filament exists and within this filament a molecular shift occurs resulting in tension and shortening, and (b) very small actin filaments located in the isotropic (light) bands slide upon and interdigitate with the larger myosin filaments located in the anisotropic (dark) bands. (4) The exact role of ATP relative to contraction and the mechanism whereby the action potential spreading throughout the muscle fiber activates the contractile system are not well established. The article also discusses various theories concerning the excitation-contraction coupling in the striated muscle, the structure and functioning of the smooth muscle, and Macromolecular periodicity—*Benjamin H. Massey.*

15. Gregg, R. A., Mastellone, A. F. and Gersten, J. W. "Cross-Exercise: A Review of Literature and Study Utilizing Electromyographic Techniques." *American Journal of Physical Medicine* **36**: 269-80; 1957.

Literature on cross-exercise is reviewed briefly. Numerous experiments were done on healthy adults to study transfer effects of graded exercise on the biceps brachii and triceps brachii muscles of the unexercised arm. Results showed overflow to contralateral muscles did not occur during nonresistive exercise or during isometric contraction of biceps brachii. Overflow, when present, appeared first in the contralateral triceps, and as stress increased action potentials appeared in contralateral biceps. A relationship between overflow and movements and fatigue was suggested.—*C. Etta Walters.*

16. Guilford, J. P. "A System of Psychomotor Abilities." *American Journal of Psychology* **71**: 164-74; March 1958.

A survey of psychomotor factors that have been found by factor analysis led to proposing a theory that psychomotor abilities may be "structured." The psychomotor

factors are classified by columns and by rows. The kinds of abilities involved are arranged in columns. They are designated as: strength, impulsion, speed, precision, coordination, and flexibility. The rows pertain to the different parts of the body involved and are classified as: gross, trunk, limbs, hand, and finger. The entire system should be regarded as a theory. Each cell in the matrix should be regarded as an hypothesis. Vacant cells in the matrix suggest undiscovered psychomotor abilities.—*Frances Z. Cumbee.*

17. HARRISON, R. H. "Duo-C.V.P. Reduces Bruises." *Clinical Medicine* S:L; June 1958.

Duo-C.V.P. (water soluble citrus bioflavonaids with ascorbic acid) was administered to 40 college football players "as a measure for lowering the incidence and minimizing the severity of the traumatic injuries sustained in contact sports." Twenty players served as the control group. The treated players showed "a definite decrease" in the occurrence and seriousness of bruises, sprains, and strains. Also of marked importance was the fact that injured players were capable of returning to active play sooner than they had in the past.—*D. B. Van Dalen.*

18. HOHMAN, L. B., BAKER, L., and REED, RUTH. "Sensory Disturbances in Children with Hemiplegia, Triplegia, and Quadriplegia." *American Journal of Physical Medicine* **37**: 1; 1958.

Forty-seven children, ages 6-16, with average or superior IQ, were tested on a number of different modalities involving sensory discrimination. Children were selected with either hemiplegia or more marked involvement on one side than the other. Examinations were on the upper extremity. Of the group, 18 of the 23 hemiplegias, 2 of the athetoid hemiplegias, 1 of the triplegias, and 12 of the 15 paraplegias showed sensory defects. The most common sensory impairments were loss of form, disturbance of two point discrimination, and loss of position sense. Other modalities were occasionally involved (light touch, sharp and dull, hot and cold, rough and smooth, wet and dry, and visual defect). In no case did one of these modalities show impairment without one of the three major defects being present. Speculation on the etiology of the cortical damage is discussed.—*C. Etta Walters.*

19. JOHNSON, ALFRED HAROLD. "The Responses of High School Seniors to a Set of Structured Situations Concerning Teaching as a Career." *Journal of Experimental Education* **26**: 4; June 1958.

One hundred and seventy high school students from four Ohio high schools were the subjects in a nonsampling descriptive investigation to determine their reaction to teaching. The chief data gathering device was a projective instrument consisting of 11 loosely structured situations dealing with teaching and with schools. The over-all results were not very favorable for the teaching profession. Reasons for not entering the teaching field were: low pay, lack of interest in teaching, discipline problems, appeal of other professions, etc. Some favorable aspects of the teaching profession were: like children, aid society, security, good hours, good people to work with, etc.—*D. B. Van Dalen.*

20. KEEN, E. N., and SLOAN, A. W. "Observations on the Harvard Step Test." *Journal of Applied Physiology* **13**: 241-43; Sept. 1958.

Two groups, one of 46 medical students and one of 22 physical education students, were given the Harvard Step test. No significant correlation was found between test scores and height, weight, leg length, or bi-iliac diameter. The results indicate no reason for lowering step for shorter adult men. In this study low post exercise rates and higher fitness indices were associated with low resting pulse rates. Physical education students, who were undergoing routine physical training, had higher fitness indices and lower resting pulse rates than the medical students.—*Peter V. Karpovich* and *Lora M. Ewing.*

21. KLEIMAN, A. H. "Hematuria in Boxers." *Journal of the American Medical Association* **168**: 1633-40; Nov. 22, 1958.

Study of 764 professional boxers revealed the presence of hematuria in 65 percent of post bout urine specimens. In 25 percent it was significant hematuria. Of these men, 237 had a tendency to recurrency. A few boxers showed the presence of blood even before the bout. Strenuous exercises alone, conducted on 25 normal individuals, caused only a slight microhematuria in five men. Boxing in itself usually produces no serious renal damage. All symptoms usually clear up within 48 hours. High incidence of post boxing hematuria depends on structural abnormalities of kidney. An observation was made that boxers who get "cut" easily had also significant hematuria. The inability to urinate for several hours after boxing was noticed in 550 boxers. White boxers had incidence of hematuria twice as high as negro boxers.

NOTE. In explaining "grunt reflex" exhibited by a boxer when he hits, the author said: "it causes the diaphragm to contract against the kidney." This is hardly the case. Grunting is a modified expiration; therefore the diaphragm relaxes and goes up.—*Peter V. Karpovich* and *Lora M. Ewing.*

22. KRONFIELD, D. S., MACFARLANE, W. V., HARVEY, NANCY, HOWARD, BETH, and ROBINSON, KATHLEEN W. "Strenuous Exercise in a Hot Environment." *Journal of Applied Physiology* **13**: 425-29; Nov. 1958.

Tests on four oarsmen were conducted in a psychrometric chamber at 80° and 112° F. before and after a six-minute exercise bout on a rowing ergometer. Immediately after exercise the average systolic blood pressure was 185 mm. Hg and the diastolic pressure fell to zero. Tachycardia, decreased hematocrit, and large loss of plasma water were also noted. Authors suggest that decrease in blood volume might be a major factor in tachycardia of severe exercise and that increased interstitial water may contribute to muscle soreness. The hotter conditions did not affect performance, but three of the four subjects became distressed during recovery at the high temperature (112°), as evidenced by markedly hyperemic skin, faintness, and some nausea. In these subjects the diastolic blood pressure remained depressed and the pulse and respiratory rates remained elevated as compared with the subject who experienced no distress. The excretion of 17-hydroxysteroids was higher in those cases where there was distress.—*Peter V. Karpovich* and *Lora M. Ewing.*

23. MALETTE, W. G., and EISEMAN, B. "Cerebral Anoxia Resulting from Hyperventilation." *Journal of Aviation Medicine* **29**: 611-15; Aug. 1958.

The deleterious effects of hyperventilation in flying personnel and interest in the relationship of hypoxia to hyperventilation prompted the intensive study of 14 dogs. Ten anesthetized dogs were hyperventilated with 100 percent oxygen using a respirator. Peripheral blood samples, brain and blood lactate measures were taken during the hyperventilation. Results indicate that hyperventilation with 100 percent oxygen produced increased concentrations of brain and femoral artery lactic acid concentrations. The authors suggest that this paradox of tissue anoxia is due to the decreased disassociation of oxygen from hemoglobin during the alkolosis and hypocapnia that accompanies the blowing off of carbon dioxide during such hyperventilation.—*Wayne D. Van Huss.*

24. MANWILLER, FLOYD V. "Expectations Regarding Teachers." *Journal of Experimental Education* **26**: 4; June 1958.

Data was secured through a personal data sheet and a questionnaire on 391 high school teachers and 134 members of boards of education. Teachers and school boards were in agreement on the behavior they thought the community expected of teachers. The area of religious life seemed to constitute the major area of agreement, the areas of economic and civic life to a lesser degree, and the areas of personal family and social-

recreational life the least. The major evidence of a possible double standard of conduct was centered in personal and social life on behaviors as they pertained to eating and drinking in taverns, smoking in public, playing cards for money, etc.—*D. B. Van Dalen.*

25. McGinnies, Elliott. "The Role of Mental Health Films in Community Discussion Groups." *Mental Hygiene* **42**: 409-22; July 1958.

This is a four-year study (nearing completion) into the role of mental health films in community discussion groups. The groups were typical of PTA and child study groups interested in public service and self-improvement. High school student groups were also used. Seventy such groups will view nine selected films dealing with child and family relations and mental health problems before completion of the project. Discussion leadership was the nondirective type, and tape recordings were made of all discussions. Experimental findings may be briefly summarized as follows:

(1) Individuals most likely to participate in discussion are those with superior education and occupying positions of leadership in the community. (2) Small groups encourage greater spontaneity of discussion and more rapid participation in discussion than large groups. (3) New participants in the discussion come in rapidly in the early stages and at a progressively slower rate in the later stages. (4) Showing of a single film with or without discussion does not necessarily result in substantial changes of opinion, but a series of films may be more effective. (5) Changes of opinion occurring in groups with discussion seem to be more lasting than in groups without discussion.

An extensive analysis was also made of the discussion content. The author presents a summary of discussant reactions to one film to indicate how this information could be useful to others showing the film for educational purposes.—*Bruce L. Bennett.*

26. Soehren, Irene. "New Treatment for Coronary Disease." *Today's Health* **35**: 18-23; Feb. 1957.

Anticoagulant drugs, in addition to older methods, now add productive years to the lives of thousands after a heart attack. Patients on anticoagulants need much more supervision than most diabetic or tubercular patients. Three criteria for giving anticoagulants are: (1) the individual must be a reliable, cooperative patient who will take his medicine and come in for his blood tests, (2) a laboratory must be available that can do a prothrombin test, and (3) the doctor must believe in and understand the use of anticoagulants. Anticoagulants which have had the best results are heparin, dicumarol, and tromexan.—*J. Grove Wolf.*

27. Weissler, A. M., *et al.* "Effects of Posture and Atropine on the Cardiac Output." *Journal of Clinical Investigation* **36**: 1656; Dec. 1957.

Twelve normal subjects were given intravenous injections of atropin sulfate to cause tachycardia. The cardiac output was then studied in the recumbent and 60 degree head up tilt. Significant increases in cardiac output were found in recumbency with little change in stroke volume. The increase was due to the increased heart rate. In the tilted group only slight elevation of the cardiac index occurred despite a greater heart rate with a fall in stroke volume. Similar results following atropine were observed during peripheral pooling of blood. Antigravity suits restored part of the cardiac response to atropine in the tilted subjects. This study supports the thesis that the central venous reservoir is an important part of cardiac response.—*Ernest D. Michael.*

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